FACTORS INFLUENCING THE ADOPTION OF WATER QUALITY BEST MANAGEMENT PRACTICES BY TEXAS BEEF CATTLE PRODUCERS

A Dissertation

by

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ABSTRACT

The management of agricultural nonpoint source pollution is complex due to the diffuse nature of the various sources. As a result, rather than relying on direct regulation, natural resource agencies generally utilize a watershed approach to encourage the voluntary adoption of best management practices (BMPs) to improve water quality and control nonpoint source pollution originating from livestock, farm, and forestry operations as well as urban nonpoint sources. Policy tools used to encourage voluntary adoption include educational programming as well as technical and financial assistance opportunities. Despite the known water quality benefits of BMPs and the availability of policy tools to encourage adoption, some landowners and livestock producers choose not to adopt conservation practices.

This study examined the current adoption behavior of Texas beef cattle producers and investigated how factors related to capacity, attitudes, environmental awareness, and farm characteristics influenced the adoption of BMPs known to reduce levels of bacteria, sediment, nutrients, and other contaminants in runoff. A statewide mail survey of beef cattle producers was conducted in the Fall of 2013. Univariate probit analysis was used to estimate the influence of 30 predictor variables on the probability of a beef cattle producer adopting 18 different water quality BMPs.

Results from the analysis show producers are adopting and maintaining water quality BMPs despite a significant lack of knowledge concerning common water quality terms and the availability of financial assistance programs to aid in practice

implementation. The most significant predictors of adoption among survey respondents included visits with Extension, prior participation in a government cost-share program, crop diversity, annual income, and percent income from the operation. The most significant factors reducing the probability of adoption among survey respondents included education, gender, visits with NRCS, membership in a livestock organization, and having a family member take over the operation. These results suggest the need to address information gaps among beef cattle producers as well as demonstrate a significant opportunity for the NRCS and Extension to forge a strategic long-term partnership to promote increased and sustained adoption of water quality BMPs.

DEDICATION

I dedicate this work to my wonderful parents, Bill and Dorothy, and to my siblings, Justin, Erin, Meredith, and Kim. Your unconditional love and unwavering support throughout the years has meant a great deal to me. My appreciation is beyond words. And finally to Mark, thank you for your continued guidance, patience, and quest for adventure.

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NOMENCLATURE

ALEC	Agricultural, Leadership, Education, and Communication
ANOVA	Analysis of variance
ATTAINS	Assessment, TMDL Tracking and Implementation System
BMP	Best management practice
CWA	Clean Water Act
DOI	Diffusion of innovations
EPA	Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
GCSP	Government cost-share program
I-Plan	Implementation Plan
LSHS	Lone Star Healthy Streams
NASS	National Agricultural Statistics Service
NEP	New Ecological Paradigm
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NPS	Nonpoint source
SCS	Soil and Crop Sciences
SWCD	Soil and Water Conservation District
TCEQ	Texas Commission on Environmental Quality
TMDL	Total Maximum Daily Load

TPB	Theory of planned behavior
TRA	Theory of reasoned action
TSSWCB	Texas State Soil and Water Conservation Board
TWRI	Texas Water Resources Institute
TWS	Texas Watershed Stewards
USDA	United States Department of Agriculture
WFSC	Wildlife and Fisheries Sciences
WHIP	Wildlife Habitat Incentives Program
WPP	Watershed Protection Plan
WQMP	Water Quality Management Plan

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CHAPTER I

INTRODUCTION

Excessive levels of fecal indicator bacteria (e.g. *E. coli*) remain a major cause of water quality impairment throughout Texas. According to the 2012 Texas Integrated Report for Clean Water Act Sections 305(b) and 303(d), a total of 568 impairments are included in Category 5, which is reserved for water bodies that do “not meet applicable water quality standards or are threatened for one or more designated uses by one or more pollutants” (TCEQ 2012, 1). Impairments due to elevated bacteria represent the highest percentage (45%) of those included in Category 5. Total Maximum Daily Loads (TMDLs), TMDL Implementation Plans (I-Plans), and Watershed Protection Plans (WPPs) continue to be developed by state environmental agencies and organizations to address these impairments.

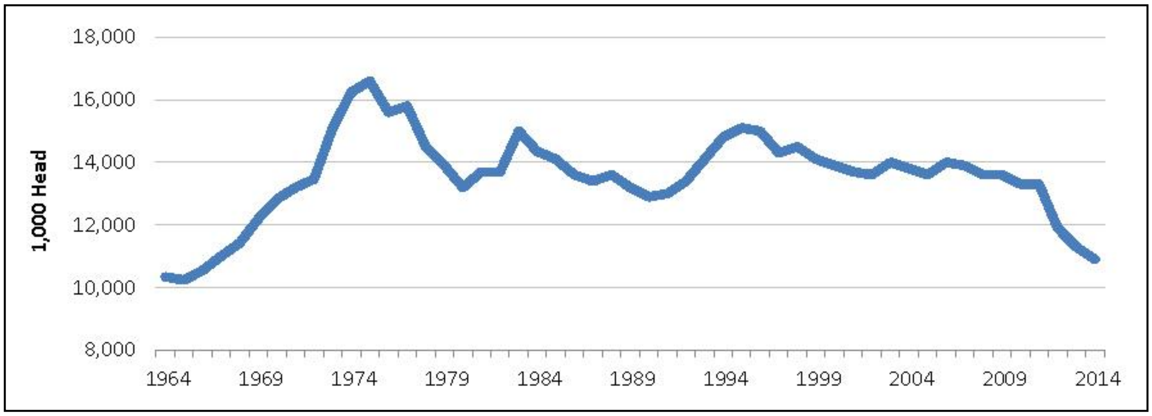
Surface water contamination by bacteria is not isolated to one watershed or region, but is instead a significant statewide issue in Texas. Fecal indicator bacteria are common inhabitants of the intestines of all warm-blooded animals. Although watersheds can be affected by microbial pollution from a wide variety of sources, livestock are increasingly under scrutiny (McAllister and Topp 2012). Mechanisms for reducing bacterial contamination from livestock species, precluding potential regulatory implications, and protecting human health include adoption, implementation, and maintenance of best management practices (BMPs) by livestock producers and landowners across the state (Hoorman and McCutcheon 2005). Despite the existence of financial assistance programs and the known water quality benefits of BMPs, many livestock producers and landowners are not adopting practices for a variety of reasons (Gillespie et al. 2007). This study aims to evaluate the potential barriers that exist regarding the adoption and implementation of water quality BMPs by Texas beef cattle producers.

1.1. Problem Statement

The Texas beef cattle industry is an important agricultural industry in the state impacting the economy and lives of its citizens. As of January 2014, Texas had a total inventory of 10.9 million head of cattle and calves (Figure 1.1; NASS 2014). This represents a 4% decrease since January 2013 and the lowest January inventory since 1966 (NASS 2014). Despite this decline, Texas still ranks first in total number of cattle and calves with 12% of the total U.S. cattle inventory (NASS 2014). Texas also ranks first in the nation in total number of beef cows, beef cattle operations, and fed cattle. The total economic value added by meat animals in Texas is estimated to be over $7 billion dollars.

The 2007 Census of Agriculture indicates there are 137,769 farms in the state raising 4 million beef cattle with approximately 92% of operators owning between 1 and 99 head. An interesting trend over the past decade concerns the shift toward smaller farm sizes. Between 2002 and 2007, the number of farms smaller than 9 acres increased by almost 75%, whereas the number of farms larger than 500 acres decreased by 10%. These smaller farms tended to have younger operators who also had off-farm jobs. This

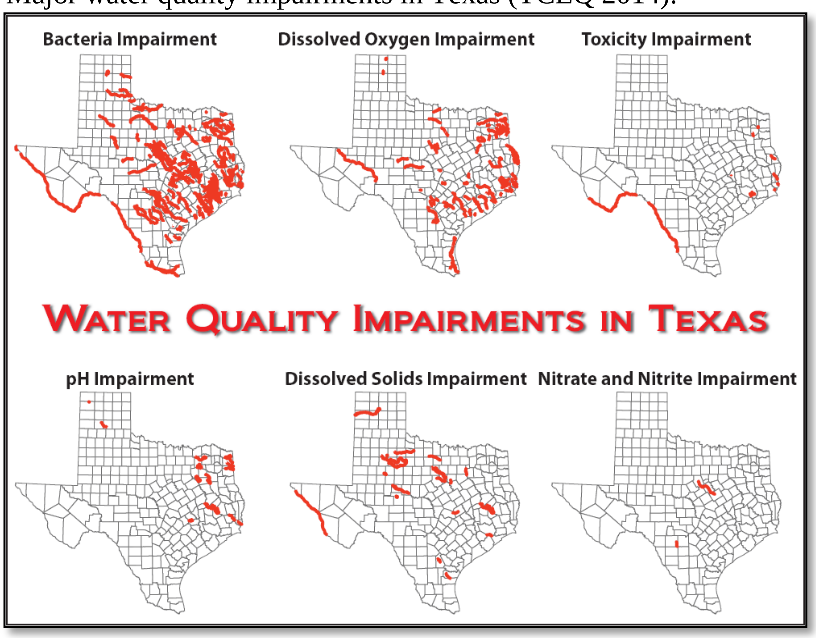
Figure 1.1
Inventory of Texas cattle and calves from 1964 to 2014 (NASS 2014).



pattern suggests an increased number of livestock are being concentrated on smaller tracts of land and these livestock are being owned by landowners with varying levels of experience in livestock production and land management as well as various levels of understanding regarding watersheds and water quality. In a survey of Texas citizens, approximately 50% of all respondents marked "I don't know" when asked about conditions and activities affecting water quality (Boellstorff et al. 2010). This evidence suggests an enormous level of disconnect exists between the average Texas citizen and their impacts on water quality.

According to the US Environmental Protection Agency's (EPA) Assessment, TMDL Tracking and Implementation System (ATTAINS) database (2013), Texas has approximately 191,000 miles of streams and rivers; nearly 2 million acres of lakes, reservoirs and ponds; and more than 2,300 square miles of bays and estuaries. Approximately 44% of the state's river and stream miles (10,321 miles), 38% of the state's lakes, reservoirs, and ponds (561,909 acres), and 28% of the state's bays and estuaries (1,690 square miles) are considered impaired. By far, the most overwhelming cause of impairment in Texas' surface bodies of water is excessive levels of bacteria, specifically *Escherichia coli* (*E. coli*; Figure 1.2). Bacterial contamination is responsible for the impairment of over 7,100 miles of the state's assessed river and stream segments alone. The EPA estimates agricultural sources are responsible for nearly 20% of all the surface water impairments in Texas. Results from bacterial source tracking studies conducted in the Attoyac Bayou, Leona River, Big Cypress Creek, Copano Bay, Lampasas River, and Leon River Watersheds in Texas all identify cattle as contributing 4% to 20% of the bacteria (averaging 13%).

Figure 1.2
Major water quality impairments in Texas (TCEQ 2014).



Clearly, the livestock sector is not solely responsible for the water quality impairments in Texas; all land uses contribute to the current water quality problems and all land uses can contribute to innovative solutions. Specifically concerning the livestock industry, however, BMPs have been developed for pasture, runoff, riparian area, manure, and mortality management (Redmon et al. 2012). When implemented, these BMPs can help minimize bacterial contamination as well as sediment and nutrient contamination of Texas' surface waters.

1.2. Justification

Texas livestock producers are generally regarded as good stewards of the environment. However, concern remains high regarding the complex relationship between activities associated with livestock production and their impacts on environmental quality. Texas currently faces numerous critical issues related to water quality and water resource management. A significant portion of surface waters in Texas are impaired and do not meet their designated uses for contact recreation, fish consumption, or water supply. Projections that the state's population will double by 2040 further fuel concerns that both the quality and quantity of water needed by citizens will not be sufficient. Individual and community action at the watershed level are essential to restore, protect, and conserve Texas' vital water resources.

A significant amount of research has been conducted on the efficacy of BMPs in removing contaminants (e.g., sediment, pesticides, nutrients, pathogens) from runoff. Although results vary, overwhelming evidence exists to suggest BMPs, if installed and maintained correctly, can help improve water quality. Furthermore, research has been conducted on the extent of BMP adoption in the agricultural sector and more specifically, potential barriers that individuals may face when choosing whether to adopt one or more BMP. However, there is no evidence in the literature to suggest any research has been conducted specifically for Texas livestock producers. In addition, few studies examine the barriers responsible for hindering the adoption of water and livestock management BMPs (Prokopy et al. 2008).

A better understanding of the BMP adoption behavior of Texas livestock producers, specifically beef cattle producers, will enable state water quality and natural resource agencies to improve the design of practices and programs that encourage and secure participation, facilitate sustained adoption of practices, and meet water quality goals in the most cost-effective manner.

1.3. Objectives of the Study

The overarching goal of this research is to promote increased adoption and sustained management of conservation practices by agricultural producers that protect water resources and further the potential to achieve the goals of the Clean Water Act. To address this overarching goal, this study assessed the extent of current adoption and maintenance of water quality BMPs by Texas beef cattle producers and evaluated how factors related to capacity, environmental awareness, attitude, and farm characteristics (Prokopy et al. 2008) affected a producer's decision to adopt one or more water quality BMP(s).

Specific objectives of the study were to:

1. Review and summarize current water quality protection efforts in Texas, including educational, technical, financial assistance programs, as well as literature regarding effectiveness and barriers to adoption of BMPs in the agricultural sector.
2. Develop and administer a statistically valid, statewide survey of beef cattle producers to quantitatively assess the extent to which variables related to capacity, environmental awareness, attitude, and farm characteristics influence producer adoption of water quality BMPs.
3. Identify specific barriers associated with producer adoption of water quality BMPs and participation in government-funded conservation programs.
4. Develop recommendations for policy makers and conservation program managers that increase voluntary adoption and sustained management of water quality BMPs.

The first objective will be addressed in the following sections with a detailed outline of the regulatory framework that exists within Texas to protect water quality as well as the educational, technical, and financial assistance programs that target livestock producers in the state. The first objective will also be addressed in Chapter 2 (Review of the Literature) of this document with an extensive review of the literature concerning water quality BMPs for the beef cattle industry and the barriers to the adoption of BMPs in the agricultural sector. The second and third objectives will be addressed in Chapters 3 (Methodology) and 4 (Results) of this document. Lastly, the fourth objective will be addressed in Chapter 5 (Summary and Conclusions).

1.4. Background

1.4.1. History of Water Quality Regulation in the United States

Growing public awareness and concern regarding increased pollution of our nation's waters was the main impetus for the passing of the first major US law in 1948 to address water contamination (EPA 2012). This law was known as the Federal Water Pollution Control Act and was the culmination of nearly 100 previous attempts by legislators and environmentalists to pass water pollution legislation during the first half of the 20th century (Rodgers 1992, Landsberg 2004). Rapid and largely uncontrolled industrial and urban growth following the end of World War II finally pushed Congress into action after many of the nation's lakes, rivers, and streams notoriously caught on fire or were deemed to be septic waste pools (Adler et al. 1993). As part of the 1948 legislation, the Senate Committee on Public Works declared "pollution of our water resources by domestic and industrial wastes has become an increasingly serious problem due to the rapid growth of our cities and industries.... Polluted waters menace the public health (through contamination of water and food supplies), destroy fish and game life, and rob us of other benefits of our natural resources" (House Report no. 1829, to accompany Senate Bill 418, 80th Congress, 2d session, April 28, 1948).

Although a step in the right direction, the Federal Water Pollution Control Act lacked the organization and design to effectively improve and protect the quality of our nation's waters (Barry 1970). After continued public outcry and recognition of the shortcomings of the 1948 law, Congress enacted sweeping amendments in 1972, 1977, and again in 1987. Known today by its more common name, the Clean Water Act

(CWA) forms the foundation for surface water quality protection in the United States. The CWA requires individual states to set standards for surface water quality; it also requires public and private facilities to acquire permits for discharging wastewater. In addition, the CWA stipulates citizen participation be included in various stages of these requirements. At the federal level, the EPA is responsible for administering the water quality standards outlined in the CWA. However, the EPA typically delegates water quality management at the state level to the primary state environmental agency.

1.4.2. Water Quality Management in Texas

As the primary environmental agency in Texas, the Texas Commission on Environmental Quality (TCEQ) has primary jurisdiction for water quality management planning; issuance of permits for point source dischargers; abatement of urban nonpoint source pollution; and enforcement of rules, standards, orders, and permits related to water quality. In 1991, the Texas Legislature delegated a portion of the authority for water quality management to the Texas State Soil and Water Conservation Board (TSSWCB). The TSSWCB is responsible for administering the state's soil and water conservation law and for managing programs to prevent and reduce nonpoint source pollution from agriculture and silviculture.

Under the CWA and Chapter 26 of the Texas Water Code, TCEQ has sole authority to develop and amend surface water quality standards for the state. Under the CWA, Texas must define how water bodies will be used and must develop and enforce a comprehensive set of water quality standards for each specific use. Every three years, Texas is required to evaluate its water quality standards and, if necessary, revise them to keep in accordance with federal laws and guidelines. The EPA is required to review state water quality standards to ensure they meet the goals outlined in the CWA.

There are three parts to the Texas Surface Water Quality Standards: (1) designated uses; (2) chemical, physical and biological criteria to protect those uses; and (3) an antidegradation policy designed to prevent the deterioration of existing levels of good water quality.

Five designated uses of water are defined in the Texas Surface Water Quality Standards:

1. Aquatic life use
2. Contact recreation
3. Fish and shellfish consumption
4. Public water supply
5. General uses (navigation, water supply for agriculture and industry, sea grass propagation, wetland functions, etc.)

For each body of water where these designated uses are attainable, upper and lower limits for common biological, chemical, and physical water quality parameters are established. These include standards for dissolved oxygen, temperature, pH, total dissolved solids, fecal bacteria, and toxic limits. Any water body exceeding the accepted limits of any of these parameters is considered an impaired water body that cannot support some or all of its designated uses.

The third part of the state water quality standards is antidegradation. Under the CWA, Texas is responsible for developing an antidegradation policy for maintaining the quality of the state’s water bodies. In essence, this policy protects clean waters from becoming impaired and prohibits impaired water bodies from becoming more impaired.

Texas must regularly monitor its water bodies to determine whether they meet state and federal water quality standards. Water quality testing and monitoring are the responsibility of the TCEQ. The results obtained from testing and monitoring provide the basis for effective policies that promote the protection, restoration, and wise use of surface waters in Texas.

To comply with Section 303(d) of the CWA, the TCEQ is required to identify water bodies failing to meet or not expected to meet water quality standards and thus not supporting their designated uses. All impaired water bodies not meeting water quality standards for their assigned designated uses are placed on the state 303(d) List, which must be submitted to the EPA every two years for review and approval.

In Texas, remediation of 303(d) listed water bodies is done through development of a Total Maximum Daily Load (TMDL), a Watershed Protection Plan (WPP), or in some cases, both. A TMDL is mandated by Section 303(d) of the CWA and is a calculation of the maximum amount of a specific pollutant a water body can receive (loading capacity) and still meet water quality standards for its assigned designated use(s). TMDLs apply to both point and nonpoint sources of pollution, but focus on a singular pollutant. For example, if a water body is listed as not meeting standards for bacteria, pH, and dissolved oxygen, three TMDLs would be required to be written. The second phase in a TMDL project typically involves development of an implementation plan (I-Plan), although this phase is not a requirement. An I-Plan outlines regulatory (for point sources) and voluntary corrective actions (for nonpoint sources) needed to reduce the particular pollutant(s) of concern so the water body will meet surface water quality standards and thus support its designated use(s).

A WPP is a coordinated framework for implementing prioritized and integrated water quality protection and restoration strategies driven by state environmental objectives. In contrast to a TMDL, a WPP takes a more holistic approach to watershed management by focusing on all water quality impairments and all potential sources of pollution in the watershed. The ultimate goal of a WPP is to generate a holistic plan that provides guidance for implementing conservation and management practices to minimize contamination and assure the long-term health of the watershed.

1.4.3. Point and Nonpoint Sources of Pollution

The EPA has defined two major sources of pollution—point and nonpoint. Point source pollution is pollution discharged from a clearly defined, fixed point such as a pipe, ditch, channel, sewer, tunnel, or concentrated animal feeding operation. Agricultural stormwater discharges and return flow from irrigated agriculture are specifically excluded from the definition of point source. As stipulated by the CWA, any facility discharging wastewater directly to surface water must obtain a National Pollutant Discharge Elimination System (NPDES) permit from the EPA or the state (EPA 2009). Discharged wastewater, whether treated or not, can contain pathogens and other substances that can be harmful both to aquatic and human life. Untreated or partially treated wastewater can also lower the amount of dissolved oxygen in streams and rivers, reducing the quality of the water as habitat for aquatic plants and animals.

Nonpoint source pollution (NPS) is pollution that does not originate from a clearly defined, fixed location. The term nonpoint source is defined to mean any source of water pollution that does not meet the legal definition of point source in section 502(14) of the Clean Water Act. NPS pollution originates from many diffuse sources across the landscape, most of which cannot readily be identified (Table 1.1). For this reason, NPS monitoring and regulation is difficult because the contaminants are not easily traceable to an exact source or point of origin. As a result, voluntary BMPs are generally utilized to address NPS issues. NPS pollutants are generally carried off the land by runoff from stormwater or excess irrigation. As the runoff moves over the land, it picks up and carries away natural and man-made pollutants, finally depositing them in surface water and even in underground sources of drinking water.

Both point and nonpoint sources of pollution have, to some degree, affected all of Texas' 15 inland river basins and eight coastal basins, several of its reservoirs, and all of its estuaries, coastal wetlands, and bays. As a result of the CWA, both the United States and Texas have experienced significant progress in protecting and restoring the quality of surface water resources. The majority of this progress can be attributed to regulations specifically designed to reduce contributions from point source dischargers. In contrast, very limited success has been achieved with reducing pollution from nonpoint sources (Houck 1999).

According to the EPA (2013), 53% of our nation's rivers and streams remain impaired today and roughly 75% of these impairments are a result of nonpoint sources of pollution originating from streets, farms, mines, yards, parking lots, and other sources. In

Texas, 44% of the assessed rivers and streams are considered impaired with nearly 63% of these impairments attributed to nonpoint sources of pollution. However, solving nonpoint source water quality problems will require more than just laws and regulations.

Table 1.1
Types of nonpoint source pollutants and their effects (San Francisco Bay Conservation and Development Commission 2003).

Pollutant	**Nonpoint Source**	**Effects**
Bacteria	Livestock and pet waste, wildlife, septic systems, and boat discharge.	Introduces disease-bearing organisms to surface water and ground water, resulting in shellfish bed closures, swimming restrictions, and contaminated drinking water.
Nutrients (nitrogen and phosphorus)	Fertilizers, livestock and pet waste, wildlife, septic systems, suburban/urban development, soil erosion.	Promotes algal blooms and aquatic weed growth, which can deplete oxygen, increase turbidity, alter habitat conditions, cause fish kills, and decrease biodiversity.
Sediment (soil)	Construction, driveways, ditches, earth removal, dredging, mining, gravel operations, agriculture, road maintenance, forest operations, soil erosion, stream bank erosion.	Increases surface water turbidity, which reduces plant growth and alters food supplies for aquatic organisms, decreases spawning habitat and cover for fish, interferes with navigation and increases flooding.
Toxic and hazardous substances	Landfills, junkyards, underground storage tanks, hazardous waste disposal, mining, pesticides/herbicides, auto maintenance, runoff from highways and parking lots, boats, marinas, illegal dumping, oilfield activity.	Accumulates in sediment, posing risks to bottom-feeding organisms and their predators, contaminates ground and surface drinking water supplies, lead to fish closures, some contaminants may be carcinogenic, mutagenic and/or teratogenic and can bioaccumulate in tissues of fish and other organisms, including humans.

Success will depend not only on the commitment and participation of stakeholders, but also on a holistic approach that focuses on protecting or restoring key watershed processes affecting the interaction of water, sediment, plants, and animals (Hidding and Teunissen 2002, Dale et al. 2000, Gove et al. 2001).

BMPs targeted toward livestock producers aim at controlling nonpoint sources of pollution originating from agricultural lands. Several studies have shown the potential for agricultural activities to generate pollutants including sediment, nutrients (nitrogen and phosphorus), pesticides, salts, and pathogens (Table 1.2; EPA 1998, Kahn 1998, Knutson et al. 1998, Ribaudo et al. 1999). Specific BMPs can be designed based on the pollutant in question, the topography of the land, and the associated climate to help minimize contamination of surface waters. Appropriate combinations of these practices can be a very effective and practical approach to reducing water pollution from agricultural activities.

1.4.4. Bacterial Contamination in Texas Surface Water

According to the 2012 Texas Integrated Report for CWA Sections 305(b) and 303(d), there were a total of 568 impairments in Texas. Of these impairments, 45% were due to elevated bacteria. As of February 2012, a total of 206 TMDLs have been developed for 134 water segments in Texas.

Fecal bacteria are microscopic organisms found in the feces of humans and other warm-blooded animals. By themselves, they are usually not harmful, but they are important because they are indicator species and can suggest the presence of pathogenic (disease-causing) organisms. Pathogenic organisms include bacteria, viruses, or parasites that can cause waterborne illnesses such as typhoid fever, dysentery, and cholera. In addition to the potential health risks, elevated bacteria levels can also cause unpleasant odors, cloudy water, and increased oxygen demand.

Table 1.2
Nonpoint source pollution originating from agricultural activities and their impact on water quality (adapted from Ongley 1996).

Agricultural Activity	**Effects**	
	Surface Water	**Ground Water**
Tillage/Plowing	Sediments carry phosphorus and pesticides adsorbed to sediment particles; siltation of river beds and loss of habitat, spawning ground, etc.	—
Fertilizers	Runoff of nutrients (nitrogen and phosphorus), leading to eutrophication; taste and odor problems in public water supplies; excess algae growth leading to hypoxia and fish kills.	Leaching of nitrate to groundwater; excessive levels are a threat to public health.
Manure spreading	Spreading on frozen ground or near surface water results in high levels of contamination by pathogens, metals, phosphorus and nitrogen leading to eutrophication and potential contamination.	Contamination, especially by nitrogen.
Pesticides	Runoff of pesticides contaminates surface water, inhibits growth and reproduction in wildlife; public health affected when people eat contaminated fish. Pesticides can be carried by wind over very long distances and contaminate aquatic systems miles away.	Some pesticides may leach into groundwater, causing human health problems from contaminated wells.
Feedlots/Animal corrals	Contamination of surface water with pathogens (bacteria, viruses, etc.), leading to chronic public health problems. Also contamination by nutrients and metals contained in urine and/or feces.	Potential leaching of nitrogen, metals, etc. to groundwater.
Irrigation	Runoff of salts causes salinization of surface waters; runoff of fertilizers and pesticides causes ecological damage, bioaccumulation in edible fish species, etc. High levels of trace elements such as selenium can cause serious ecological damage and potential human health problems.	Enrichment of groundwater with salts, nutrients (especially nitrate).

The most common types of fecal bacteria measured to indicate the potential presence of harmful pathogens include total coliform, fecal coliform, fecal streptococci, enterococci, and *E. coli*. The EPA recommends *E. coli* as the most reliable indicator of contamination for freshwater and enterococci as the most reliable indicator in saltwater.

Bacteria in Texas waterways can originate from many sources across the landscape including:

- Wastewater treatment plants, especially from plants not up to code or functioning properly
- Leaky septic systems
- Pet waste
- Runoff from neighborhood streets and parking lots
- Wildlife, including deer, feral hogs, rodents, and large flocks of birds resting on public waters
- Combined sewer overflows
- Leaking sewer lines
- Livestock (Table 1.3)

The behavior of bacteria in water is not well understood because it involves many complex factors in the environment and in the organisms themselves. As a result, it can be a challenge to reduce their levels in waterways.

Table 1.3
Fecal coliform production for major classes of livestock and feral hogs (TCEQ 2008).

Class of Livestock	**Fecal coliform (10^9 cfu/day) (count/animal/day)**
Beef Cow	104
Dairy Cow	101
Sheep	12
Hog	11
Feral Hogs	11
Duck	2.43
Horse	0.4
Chicken	0.1
Turkey	0.09

Several variables can affect the fate and transport of fecal bacteria:

- Fate processes include growth (cell division), death by predation, and die-off (can be affected by temperature, pH, nutrients, toxins, salinity, and sunlight intensity; Table 1.4).
- Transport processes include advection (horizontal transport), dispersion, settling, and re-suspension from the sediment bed (can be affected by temperature, pH, nutrients, toxins, salinity, and sunlight intensity).

Computer models (Soil and Water Assessment Tool, Hydrological Simulation Program-FORTRAN) can be used to simulate the fate and transport of bacteria at the watershed-scale, however, the predictive strength of these models depends highly on the accuracy of data entered into the model. A better comprehension of the fate and transport of bacteria is needed to understand the potential impact of the contaminant and to more effectively develop management strategies in a watershed.

1.5. Agricultural Best Management Practices

1.5.1. General Information

The EPA defines BMPs as “methods that have been determined to be the most effective, practical means of preventing or reducing pollution from nonpoint sources” (EPA 2008, no page). The type of BMP implemented depends on the specific sources and types of pollutants that are causing the problem.

The adoption and implementation of BMPs by livestock producers are generally voluntary. In some watersheds across the nation, however, nonpoint source pollution control is regulated. To help motivate producers to implement practices to protect water quality, some federal and state agencies offer financial assistance programs to help off-set a portion of the installation fees. These programs will be discussed later in this section.

Table 1.4
Potential survival of fecal pathogens in the environment (Olsen 2003).

		Duration of Survival			
Material	**Temp.**	***Cryptosporidium***	***Salmonella***	***Campylobacter***	***E. coli* O157:H7**
Water	Frozen	> 1 yr	> 6 mo	2-8 wks	> 300 d
	Cold (5^{o}C)	> 1 yr	> 6 mo	12 d	> 300 d
	Warm (30^{o}C)	10 wks	> 6 mo	4 d	84 d
Soil	Frozen	> 1 yr	> 12 wks	2-8 wks	> 300 d
	Cold (5^{o}C)	8 wks	12-28 wks	2 wks	100 d
	Warm (30^{o}C)	4 wks	4 wks	1 wk	2 d
Cattle manure	Frozen	> 1 yr	> 12 wks	2-8 wks	> 100 d
	Cold (5^{o}C)	8 wks	12-28 wks	1-3 wks	> 100 d
	Warm (30^{o}C)	4 wks	4 wks	1 wk	10 d
Liquid manure		> 1 yr	13-75 d	> 112 d	10-100 d
Composted manure		4 wks	7-14 d	7 d	7 d
Dry surfaces		1 d	1-7 d	1 d	1 d

In general, agricultural BMPs are designed to control sediment and other contaminants carried from agricultural lands, encourage sound pest and nutrient management techniques, protect sensitive riparian areas, properly store and utilize manure, and properly handle animal mortality to ensure economic, environmental, and agronomic sustainability. Adopting agricultural BMPs can ultimately increase efficiency and profits, increase property values, improve water quality, and benefit the local community.

Agricultural BMPs can be structural or nonstructural in nature. Structural practices, such as fences and filter strips, often involve some sort of construction, installation, and maintenance. Structures can be vegetative or non-vegetative. Nonstructural practices, on the other hand, are activities or behaviors that reflect better planning and management and increased education and awareness.

1.5.2. Best Management Practices for the Texas Beef Cattle Industry

The BMPs included in this study were selected by the Lone Star Healthy Streams (LSHS) Program Development Committee (this educational program is explained later on in this section). Members of this committee include Extension forage, dairy, poultry, wildlife, and horse specialists, as well as state natural resource agency representatives. Each committee member was asked to identify priority BMPs for the Texas beef cattle industry. A list of 18 BMPs was compiled dealing specifically with erosion and sediment control; grazing management; and mortality, nutrient, and pesticide management practices (Table 1.5). Descriptions, benefits, costs, and data on bacterial removal efficiencies are provided for each practice in Chapter 2.

Table 1.5
Best management practices for Texas livestock producers.

BMP Category	BMP
Erosion and Sediment Control Practices	Critical Area Planting
	Diversion
	Field Borders
	Filter Strips
	Grassed Waterways
	Heavy Use Area Protection
	Stream Crossing
	Stream bank and Shoreline Protection
Grazing Management	Access Control
	Fencing
	Field, Salt, and/or Mineral Locations
	In-Stream Watering Point
	Prescribed Grazing
	Shade Structure
	Watering Facility
Mortality, Nutrient, and Pesticide Management	Mortality Management
	Pesticide Management
	Soil Testing and Nutrient Management

1.5.3. Sources of Technical Assistance for BMP Implementation

Many agencies offer free consultations and resource materials to landowners and livestock producers in Texas. These agencies also routinely conduct free seminars and short courses on current information and management practices in agriculture. The agencies include local Soil and Water Conservation Districts, the Texas State Soil and Water Conservation Board, the USDA–Natural Resources Conservation Service (NRCS), and the Texas A&M AgriLife Extension Service.

1.5.3.1. Soil and Water Conservation Districts

Soil and Water Conservation Districts (SWCDs) offer technical assistance to farmers and ranchers in preparing soil and water conservation plans to meet each land unit's specific capabilities and needs. Plans include appropriate land treatment practices, production practices, and management and technology measures to prevent or abate pollution to meet state water-quality standards.

A SWCD, much like a county or school district, is a subdivision of state government. The program and plan of work of the district are developed according to the local needs of the district. This process gives local farmers and ranchers the opportunity to decide for themselves how to solve local soil and water conservation problems.

SWCD programs in Texas are coordinated by the Texas State Soil and Water Conservation Board (TSSWCB). There are currently 216 SWCDs in the state. The TSSWCB offers technical assistance funds to SWCDs through a grant program. Personnel hired under this program are district employees who work cooperatively with the NRCS to help agricultural landowners/operators plan and install conservation practices. The NRCS has a unique partnership with SWCDs. All 216 districts in Texas have working mutual agreements with the US Department of Agriculture (USDA) to provide grassroots input to the USDA through the NRCS. Districts also work with the USDA Farm Service Agency, the Texas A&M AgriLife Extension Service, the Texas A&M Forest Service, US Forest Service and others when necessary to help agricultural landowners/operators meet individual land-use needs.

In addition, the passage of Senate Bill 503 in 1993 created the Texas Water Quality Management Plan (WQMP) Program. This program provides agricultural and silvicultural (forestry) producers with an opportunity to comply with state water quality laws through traditional, voluntary, incentive-based programs. The plans include appropriate land treatment practices, production practices, management measures, technologies, or combinations thereof. Each plan aims to prevent or reduce pollution to meet state water quality standards as determined by the TSSWCB in consultation with local SWCDs.

1.5.3.2. Texas State Soil and Water Conservation Board

The TSSWCB offers technical assistance to the state's 216 SWCDs. The TSSWCB was created in 1939 by the Texas Legislature and is the lead agency in Texas for planning, implementing, and managing programs and practices to reduce agricultural and silvicultural nonpoint source pollution.

The primary means for achieving this goal is through WQMPs, which are site-specific plans developed through and approved by SWCDs for agricultural or silvicultural lands. Five regional offices help local districts and landowners develop these plans.

The TSSWCB also works with other state and federal agencies on nonpoint source pollution issues as they relate to the state water quality standards, TMDLs, WPPs, and the Coastal Management Plan.

1.5.3.3. Natural Resources Conservation Service

The Natural Resources Conservation Service (NRCS) helps landowners and managers improve and protect their soil, water, and other natural resources. For decades, private landowners have voluntarily worked with NRCS (previously Soil Conservation Service) specialists to prevent erosion, improve water quality, and promote sustainable agriculture. The agency employs soil conservationists, rangeland management specialists, soil scientists, agronomists, biologists, engineers, geologists, engineers, and foresters. These experts help landowners develop conservation plans, create and restore wetlands, and restore and manage other natural ecosystems. Through the Conservation Technical Assistance program, the NRCS provides information to landowners and livestock producers concerning resource assessment, practice design, resource monitoring, and follow-up of installed practices.

1.5.3.4. Texas A&M AgriLife Extension Service

The mission of the Texas A&M AgriLife Extension Service is to provide community-based education to Texans. Its network of 250 county Extension offices and more than 900 professional educators makes expertise available to every resident in every Texas county. The county extension agents and specialists are a technical resource for agricultural producers throughout the state. In addition, the Texas A&M AgriLife Bookstore provides access to a wealth of information and publications regarding water quality, watershed management, and livestock.

1.5.4. Sources of Financial Assistance for BMP Implementation

Financial assistance for implementing BMPs is provided primarily through the Texas State Soil and Water Conservation Board, Natural Resources Conservation Service, and USDA Farm Service Agency.

1.5.4.1. Texas State Soil and Water Conservation Board

In addition to technical assistance, the TSSWCB can also offer financial assistance for the implementation of BMPs. Two programs offered by the TSSWCB provide financial assistance for the implementation of water quality management plans (WQMP) and the installation of BMPs:

- *Water Quality Management Plan Program*: Provides financial assistance to eligible landowners for WQMP implementation of up to 75% cost-share assistance for approved practices with a maximum of $15,000 per plan. Landowners and operators may request the development of a site-specific water quality management plan through local SWCDs. Plans include appropriate land treatment practices, production practices and management and technology measures to achieve a level of pollution prevention or abatement consistent with state water quality standards.
- *The Clean Water Act Section 319(h) Nonpoint Source Grant Program*: The EPA distributes CWA 319 funds to state agencies involved in water quality management (in Texas, the TCEQ and TSSWCB). This assistance provides funding for various types of projects working to reduce nonpoint source water pollution. Funds may be used to conduct assessments, develop and implement TMDLs and watershed protection plans, provide technical assistance, demonstrate new technology, and provide education and outreach.

1.5.4.2. Natural Resources Conservation Service

The Environmental Quality Incentives Program (EQIP) is the primary program offered by the NRCS for implementing BMPs. EQIP is a voluntary conservation program supporting production agriculture and environmental quality. The program provides funding to farmers and ranchers to implement BMPs. It is designed to address both locally identified resource concerns and state priorities. In FY 2011, the Texas allocation for EQIP was just under $58 million. The amount of funding available for

EQIP varies among counties. To be eligible for this program, a person must be involved in livestock or agricultural production and develop a plan of operations. This plan defines the objective to be achieved by the conservation practice proposed and a schedule of practice implementation. Applications are then ranked by the environmental benefits achieved and the cost effectiveness of the proposed plan.

The NRCS also offers other programs for BMP implementation:

- *Agricultural Water Enhancement Program (AWEP)*: This is part of the EQIP program and is a voluntary conservation initiative providing technical and financial assistance to landowners and livestock producers to implement agricultural water enhancement activities on agricultural lands. AWEP operates through program contracts with producers to plan and implement conservation practices in project areas established through partnership agreements.
- *Grassland Reserve Program*: A voluntary program that helps landowners and operators restore and protect grassland.
- *Cooperative Conservation Partnership Initiative*: A voluntary program that enables the use of certain conservation programs along with resources of eligible partners to provide financial and technical assistance to owners and operators of agricultural lands.
- *Conservation Security Program*: Provides financial and technical assistance to promote conservation and natural resource improvement.
- *Wetlands Reserve Program*: Provides technical and financial support for landowners restoring wetlands.

- *Wildlife Habitat Incentives Program*: Provides financial incentives to develop habitat for fish and wildlife on private lands.

1.5.4.3. USDA Farm Service Agency

The Farm Service Agency administers several programs that can help in BMP implementation, including the Conservation Reserve Program, Conservation Reserve Enhancement Program, and Source Water Protection Program.

- *Conservation Reserve Program (CRP)*: This program provides annual rental payments and cost-share assistance to establish long-term, resource-conserving ground covers on eligible farmland. It helps agricultural producers safeguard environmentally sensitive land through practices that improve the quality of water, control soil erosion, and enhance wildlife habitat. After enrollment, the agency will pay an annual per-acre rental rate and provide up to 50% cost-share assistance for practices that accomplish the above goals. The portions of property to be submitted to the program will be under contract for 10 to 15 years and cannot be grazed or farmed. To be eligible for the program, agricultural producers must have owned or leased the land for at least one year before the application. For continues CRP sign-up, the land submitted must be suitable for these BMPs:
    - Riparian buffers
    - Wildlife habitat buffers
    - Wetland buffers
    - Filter strips

    - Wetland restoration
    - Grass waterways
    - Contour grass strips
- *Conservation Reserve Enhancement Program*: This voluntary land retirement program helps agricultural producers protect environmentally sensitive land, decrease erosion, restore wildlife habitat, and safeguard ground and surface water. Contracts associated with this program require a 10 to 15 year commitment to keep lands out of agricultural production. Once under contract, landowners receive a federal annual rental rate plus cost-share of up to 50% of the eligible costs to install the practice. Further, the program generally offers a sign-up incentive for participants to install specific practices.
- *Source Water Protection Program*: This program is a joint effort between the Farm Services Agency and the National Rural Water Association. It is designed to prevent source water pollution through voluntary practices implemented by producers at the local level. Full-time rural source water technicians are hired through the program that work with local NRCS conservation specialists to create source water protection plans to promote cleaner water.

1.5.5. Water Quality Education Programs in Texas

In addition to technical and financial assistance programs, some educational programs have been developed to help encourage the adoption of BMPs by Texas landowners and livestock producers. Lone Star Healthy Streams (LSHS) is a program developed by the Texas A&M AgriLife Extension Service, the TSSWCB, and the Texas

Water Resources Institute. The program's major goal is the protection of Texas waterways from bacterial contamination originating from beef cattle, dairy cattle, horses, poultry, and feral hogs that may pose a health risk to Texas citizens. LSHS educates Texas farmers, ranchers, and landowners about proper grazing, manure management, mortality management, feral hog management, and riparian area protection to reduce the levels of bacterial contamination in streams and rivers. The program consists of five resource manuals targeting each of the animal categories as well as associated PowerPoint presentations. The resource manuals include information on BMPs that can be used for each animal class to help reduce bacteria contributions to Texas waterways. The program is delivered through distance and face-to-face educational training events.

Texas Watershed Stewards (TWS) is a program developed by the Texas A&M AgriLife Extension Service and the TSSWCB to provide science-based, watershed education to help citizens identify and take action to address local water quality impairments. TWS is a comprehensive, one-day training program designed to increase citizen understanding of watershed processes and to empower local stakeholders to take an active role in the management and protection of their water resources. The curriculum is comprised of five units including a program introduction, an overview of watershed systems, an overview of watershed impairments, watershed management and regulation, and community-driven watershed protection strategies. The program is delivered through face-to-face watershed-based trainings.

CHAPTER II

REVIEW OF THE LITERATURE

This chapter is subdivided into three sections. The first section references relevant literature for the 18 BMPs included in this study and provides information on the benefits, implementation costs, and data on bacterial removal efficiencies. The second section discusses literature relevant to the adoption of conservation practices in the agricultural sector. Included in this section is research on the characteristics of producers and the livestock operation that serve as motivations or barriers to the adoption of conservation practices. The third section discusses research related to environmental attitude, specifically the New Ecological Paradigm (NEP).

2.1. Best Management Practices and Bacteria Removal Efficiencies

An extensive review of the literature was conducted to find information relevant to the 18 BMPs included in this study. Below is a summary of each of the BMPs including practice descriptions, benefits to producer, bacteria removal efficiency data, and implementation costs.

2.1.1. Access Control

- Description. Excluding livestock, people, or vehicles from restricted or environmentally sensitive areas.
- Benefits to producer. Access control can provide the following benefits:
    - Reduces herd health risks associated with livestock standing in muddy areas, such as foot disease and injuries due to unstable footing.

    - Decreases herd injuries associated with cattle climbing steep and unstable stream banks.
    - Improves water quality by reducing sediment, nutrient, bacterial, organic, and inorganic loading to the stream.
    - Reduces stream bank destabilization and associated erosion due to trampling and overgrazing of banks.
    - Allows for regeneration of riparian zone vegetation to act as a full or partial buffer.
    - Greater distribution of grazing and utilization of forage.
- <u>Bacterial removal efficiency</u>. Access control is typically used in conjunction with other conservation practices including Fencing (NRCS Code 382) and Prescribed Grazing (NRCS Code 528). These practices have been shown to reduce concentrations of bacteria.
- <u>Additional benefits</u>. Access control can result in the following additional natural resource benefits:
    - Decreased velocity of concentrated runoff which in turn increased infiltration potential with use of riprap (Massachusetts Department of Environmental Protection 2003).
    - Prevented leg injuries cattle may suffer on muddy banks, and eliminated the possibility of cows calving by the water, where newborns are more likely to suffer hypothermia and death.

- Reduced sediment and nutrient yields from streams draining pastures (Owens et al. 1996, Sheffield et al. 1997, Line et al. 2000).
- Reduced stream turbidity by 49% with use of fencing (Lombardo et al. 2000).
- Increased height and vigor of riparian vegetation with use of fencing (Odion et al. 1988, Kondolf 1993, Knapp and Matthews 1996, Kauffman et al. 1997, Dobkin et al. 1998, Ranganath et al. 2009).
- Reduced annual sediment concentration by more than 50% and decreased the amount of soil lost by 40% with use of fencing (Owens et al. 1996).
- Reduced total phosphorus levels 76% and sediment loads by 82% as a result of stream bank fencing (Line et al. 2000).
- Increased fish production by 184% as a result of fencing (Bowers et al. 1979).
- Increased ranch profits by 50% as a result of livestock exclusion (Richards and George 1996).
- Reduced suspended sediment by 8% and nitrogen loads by 34% as a result of livestock exclusion (Portneuf SWCD 2008).
- Runoff from a heavily grazed pasture (1.35 AUM/acre) was 1.4 times greater than from a moderately grazed pasture (2.42 AUM/acre), and 9 times greater than from a lightly grazed pasture (3.25 AUM/acre) (Kaufmann and Krueger 1984).

    - Increased fish production by 184% where livestock use was light (Bowers et al. 1979).
    - Reduced soil compaction under light to moderate grazing intensities (Tate et al. 2004).
    - Increased infiltration, runoff attenuation, and soil moisture retention when appropriate rest periods are utilized (Ratliff et al. 1972).
    - Enhanced herbaceous plant diversity (Marty 2005).
    - Control of noxious weeds as a result of prescribed grazing (DiTomaso 2000, Frost and Launchbaugh 2003).
- Estimated installation costs. The NRCS estimates installation costs to be \$5.01/acre to \$18.03/acre depending on method of access control used

2.1.2. Critical Area Planting

- Description: Planting vegetation, such as trees, shrubs, vines, grasses, or legumes on highly erodible or critically eroding areas (NRCS 2002). This practice involves establishing permanent vegetation on highly erodible sites to prevent and/or minimize wind and water erosion.
- Benefits to producer. Critical area planting can provide the following benefits:
    - Reduces stream bank destabilization and associated sedimentation.
    - Maintains and improves surface and/or subsurface water quantity and quality.

- Reduces accelerated soil erosion and maintains or improves soil condition.
- Decreases runoff volume and velocity.
- Reduces concentrations of pollutants including sediment, nutrients, and bacteria.
- Provides and maintains food, cover, and shelter for wildlife.
- Increased infiltration and groundwater recharge.
- Enhances aesthetic value of the land.
- Reduces soil and water loss from land.

- Bacterial removal efficiency. Critical area planting is typically used in conjunction with other conservation practices including Fencing (NRCS Code 382) and Prescribed Grazing (NRCS Code 528). These practices have been shown to reduce concentrations of bacteria between 30 (Brenner et al. 1994) and94% (Hagedorn et al. 1999).
- Estimated installation costs. The NRCS estimates installation costs to be \$355/acre to \$895/acre depending on the degree of shaping required (i.e., for gullies) and the type of vegetation used to stabilize the land surface.

2.1.3. Diversion

- Description: A channel constructed across the slope generally with a supporting ridge on the lower side. This practice helps divert runoff water away from highly erodible areas and to an area such a filter strip designed to naturally treat runoff.

- Benefits to producer. Diversion can provide the following benefits:
    - Break up concentrations of water on long slopes, on undulating land surfaces, and on land generally considered too flat or irregular for terracing.
    - Divert water away from farmsteads, agricultural waste systems, and other improvements.
    - Collect or direct water for water-spreading or water harvesting systems.
    - Increase or decrease the drainage area above ponds.
    - Protect terrace systems by diverting water from the top terrace where topography, land use, or land ownership prevents terracing the land above.
    - Intercept surface and shallow subsurface flow.
    - Reduce runoff damages from upland runoff.
    - Reduce erosion and runoff on urban or developing areas and at construction or mining sites.
    - Divert water away from active gullies or critically eroding areas.
    - Supplement water management on conservation cropping or strip cropping systems.
- Bacterial removal efficiency. Diversions help slow runoff, trap sediment, and increase infiltration. They reduce erosion as well as the movement of bacteria, nutrients, sediment, and other pollutants from fields and pastures. They also can help prevent pollutants in areas including waste storage

structures from reaching streams. Because diversions are typically established with permanent vegetation, they are like filter strips in their ability to capture and reduce bacteria in runoff.

- Estimated installation costs. The NRCS estimates a diversion costs about $1.60 per cubic yard to build. The estimate includes costs associated with operation and maintenance, labor, and equipment.

2.1.4. Exclusionary Fencing

- Description. Fence barrier to distribute grazing and control livestock access to waterways.
- Benefits to producer*:* Exclusionary fencing can provide the following benefits:
    - Reduces herd health risks associated with livestock standing in muddy areas, such as foot disease and injuries due to unstable footing.
    - Decreases herd injuries associated with cattle climbing steep and unstable stream banks.
    - Improves water quality by reducing sediment, nutrient, bacterial, organic, and inorganic loading to the stream.
    - Reduces stream bank destabilization and associated erosion due to trampling and overgrazing of banks.
    - Allows for regeneration of riparian zone vegetation to act as a full or partial buffer.
    - Greater distribution of grazing and utilization of forage.

- Bacterial removal efficiency. Fencing resulted in the following bacterial reductions:
    - Fecal coliform:
        - 30%-94% (Brenner 1996, Brenner et al. 1994, Cook 1998, Hagedorn et al. 1999, Line 2002, Line 2003, Lombardo et al. 2000, Meals 2001, Meals 2004)
    - Fecal streptococci:
        - 30%-76% (Cook 1998, Galeone et al. 2006, Meals 2001, Meals 2004)
    - Total coliform:
        - 81% when combined with alternate water sources, filter strips, and manure management (Cook 1998)
    - *E. coli*:
        - 37%-46% when combined with protected stream crossings and stream bank bioengineering (Meals 2001, Meals 2004)
    - Fecal enterococci:
        - 57% (Line 2003)
- Additional benefits. Fencing resulted in the following benefits:
    - Increased gain in beef cattle of 0.2-0.4 lb/day (Willms et al. 1994, Buchanan 1996, Porath et al. 2002, Veira 2003, Willms et al. 2002, Dickard 1998).

- Prevention of leg injuries cattle may suffer on muddy banks, and eliminates the possibility of cows calving by the water, where newborns are more likely to suffer hypothermia and death.
- Reduced sediment and nutrient yields from streams draining pastures (Owens et al. 1996, Sheffield et al. 1997, Line et al. 2000).
- Reduced stream turbidity by 49% (Lombardo et al. 2000).
- Increased height and vigor of riparian vegetation (Odion et al. 1988, Kondolf 1993, Knapp and Matthews 1996, Kauffman et al. 1997, Dobkin et al. 1998, Ranganath et al. 2009).
- Reduced annual sediment concentration by more than 50% and decreased the amount of soil lost by 40% (Owens et al. 1996).
- Reduced total phosphorus levels 76% and sediments loads by 82% as a result of stream bank fencing (Line et al. 2000).
- Increased fish production by 184% (Bowers et al. 1979).

- Estimated installation costs. The NRCS estimates installation costs to be:
  - Permanent electric cross fence: $1.80/foot (on normal soils).
  - Four-strand barbed-wire cross fence: $2.16/foot (on normal soils).
  - Four-strand barbed-wire fence: $3.05/foot (on steep or rocky soils).

2.1.5. Filter Strips, Field Borders, and Grassed Waterways

- Description. A strip or area of herbaceous vegetation established between cropland, grazing land, or disturbed land that removes contaminants from overland flow.

- Benefits to producer: Vegetative barriers can provide the following benefits:
    - Reduces stream bank destabilization and associated sedimentation.
    - Maintains and improves surface and/or subsurface water quantity and quality.
    - Reduces accelerated soil erosion and maintains or improves soil condition.
    - Decreases runoff volume and velocity.
    - Reduces concentrations of pollutants including sediment, nutrients, and bacteria.
    - Provides and maintains food, cover, and shelter for wildlife.
    - Increased infiltration and groundwater recharge.
    - Enhances aesthetic value of the land.
    - Reduces soil and water loss from land.
- Bacterial removal efficiency: Vegetative plantings and borders resulted in the following bacterial reductions:
    - *E. coli:*
        - 57.9%-99.7% (Casteel et al. 2005, Goel et al. 2004, Mankin and Okoren 2003, Tate et al. 2006)
    - Total coliform:
        - 66.9%-99.4% (Casteel et al. 2005, Cook 1998, Goel et al. 2004, Young et al. 1980)
    - Fecal coliform:

        - 43%-100% (Cook 1998, Coyne et al. 1995, Coyne et al. 1998, Fajardo et al. 2001, Goel et al. 2004, Larsen et al. 1994, Lewis et al. 2010, Lim et al. 1998, Mankin and Okoren 2003, Roodsari et al. 2005, Stuntebeck and Bannerman 1998, Sullivan et al. 2007, Young et al. 1980)
    - Fecal streptococci:
        - 68%-83.5% (Cook 1998, Coyne et al. 1998, Mankin and Okoren 2003, Young et al. 1980)
    - Fecal enterococci:
        - 99.8%-99.97% (Casteel et al. 2005)
    - *Cryptosporidium parvum*:
        - 93.5%-99% (Atwill et al. 2002, Mawdsley et al. 1996, Miller et al. 2008, Tate et al. 2004, Trask et al. 2004)
    - *Giardia:*
        - 26% (Winkworth et al. 2008)
- Additional benefits. The use of filter strips resulted in the following benefits:
    - Reduced overland flow, increased infiltration, reduced erosion and transport of soil and its constituents (Renard et al. 1997).
    - Reduced runoff by 52% and soil loss by 53% under no-tilled conditions with use of filter strips (Gilley et al. 2000).
    - Increased sediment trapping efficiencies from 41% to 100% and infiltration efficiencies from 9% to 100% (Arora et al. 1996, Arora et al.

1993, Asmussen et al. 1977, Barfield et al. 1998, Blanco-Canqui et al. 2004/2006, Coyne et al. 1995, Coyne et al. 1998, Daniels and Gilliam 1996, Dillaha et al. 1989, Hall et al. 1983, Hayes and Hairston 1983, Helmers et al. 2005, Lee et al. 2000, Magette et al. 1989, Munoz-Carpena et al. 1999, Parsons et al. 1994, Parsons et al. 1990, Patty et al. 1997, Rohde et al. 1980, Schmitt et al. 1999, and Tingle et al. 1998).

- Increased trapping efficiencies for total phosphorus between 27% and 96% (Dillaha et al. 1989, Eghball et al. 2000, Lee et al. 2000, Magette et al. 1989, Schmitt et al. 1999, Uusi-Kamppa et al. 2000, and Young et al. 1980).
- Increased trapping efficiencies for nitrate-nitrogen between 7% and 100% (Barfield et al. 1998, Blanco-Canqui et al. 2004/2006, Dillaha et al. 1989, Eghball et al. 2000, Lee et al. 2000, Mankin and Okoren, Patty et al. 1997, Schmitt et al. 1999, and Young et al. 1980).
- Increased herbicide retention contained in runoff by 38% (Krutz et al. 2005).
- Reduced atrazine concentrations by 56% (Dillaha et al. 1985) and 93%-99% (Snyder 1998).

- <u>Estimated installation costs</u>. The NRCS estimates installation costs to be $257/acre to $310/acre depending on use of native or non-native vegetation.

2.1.6. Heavy Use Area Protection

- Description. The stabilization of areas frequently and intensively used by people, animals, or vehicles by establishing vegetation cover, surfacing with suitable materials, and/or installing needed structures.
- Benefits to producer: Heavy use area protection can provide the following benefits:
    - Reduces accelerated soil erosion and maintains or improves soil condition.
    - Improves aesthetic appearance of land.
    - Reduces herd health risks associated with livestock standing in muddy areas, such as foot disease and injuries due to unstable footing.
- Bacterial removal efficiency. Heavy use area protection resulted in a 92%-99% reduction in fecal coliform with use of mulch, straw, and seed on high use areas (Lennox et al. 2007).
- Additional benefits. Heavy use area protection resulted in the following benefits:
    - Reduced bank erosion by 50% with installation of a grade control structure to protect stream banks from heavy use by cattle (Trimble 1994).
    - Near 50% reduction in total phosphorus levels in runoff collected in plots using woven geotextile fabric to protect soil surface (Singh et al. 2007).

- Over 99% of nutrients were retained on the surface of geotextile pads used in study (Singh et al. 2007).
- Reduced soil erosion by 75-80% on a plot mulched with wheat straw (provided 61% cover) as compared to an unmulched plot (Lattanzi et al. 1974).
- Increased surface water storage and protected soil surface from raindrop impact using mulch cover (Bonsu 1983).
- Increased soil porosity between 48-59% with application of rice straw (Lal et al. 1980).
- Reduced total nitrogen concentrations in runoff by 86% with use of geotextile fabric and highly porous gravel (Gold et al. 2010).
- Reduced sediment discharge by 98% with use of compost/mulch blend (Eck et al. 2010).

- Estimated installation costs. The NRCS estimates installation costs to be $4.98/square foot.

2.1.7. In-Stream Watering Point

- Description. Provides livestock limited access to a waterway while preventing access to as much of the surrounding riparian area as possible. This technique allows cattle to drink from the stream, but reduces the amount of time they spend loafing there, thereby reducing the amount of fecal material deposited in the waterway. In most cases, the entry points livestock already use can be upgraded by properly sloping the access point and by providing a stable surface for livestock to stand on.

- Benefits to producer. In-stream watering points can provide the following benefits:
  - Prevent or minimize water degradation from sediment, nutrients, and organic materials
  - Reduce stream bank erosion
  - Enable livestock to cross or provide them a stable area to drink from the stream
- Bacterial removal efficiency. No research could be found specifically on the effect of in-stream watering points on bacteria reductions. However, one of the main goals of this BMP is to limit the amount of time that cattle spend loafing in the stream. In consequence, less fecal matter will be deposited directly into the stream, and fewer bacteria will enter the waterway.
- Estimated installation costs. Costs should be similar to those for stream crossings.

2.1.8. Feed, Salt, and/or Mineral Locations

- Description**.** The placement of feed, salt, and/or mineral locations off-stream as an attempt to improve grazing distribution and encourage livestock to move away from sensitive riparian areas.
- Benefits to producer. Proper feed location can provide the following benefits:

- Reduces herd health risks associated with livestock standing in muddy areas, such as foot disease and injuries due to unstable footing.
- Decreases herd injuries associated with cattle climbing steep and unstable stream banks.
- Improves water quality by reducing sediment, nutrient, bacterial, organic, and inorganic loading to the stream.
- Reduces stream bank destabilization and associated erosion due to trampling and overgrazing of banks.
- Increases grazing distribution.
- Increases overall herd gain.

- Bacterial removal efficiency. Supplemental feed/salt locations can be used in conjunction with other conservation practices including Fencing (NRCS Code 382) and Watering Facilities (NRCS Code 614). These practices have been shown to reduce concentrations of bacteria. Any practice that reduces the amount of time cattle spend in a stream will thus reduce the manure loading and decrease the potential for adverse affects of water pollution from grazing livestock.
- Additional benefits. Supplemental feeding locations resulted in the following benefits:
    - Increased gain in beef cattle of 0.2-0.4 lb/day (Willms et al. 1994, Buchanan 1996, Porath et al. 2002, Veira 2003, Willms et al. 2002, Dickard 1998, Stillings et al. 2003, Ares 1953).

- Increased annual net returns to ranch between $4,500 and $11,000 depending on cattle prices and precipitation levels with use of off-stream water (Stillings et al. 2003).
- Increased cattle distribution and consumption of upland forage (Workman and Hooper 1968, Bailey and Welling 1999, Stillings et al. 2003, Bailey et al. 2008, Ares 1953).
- Reduced development of uncovered and unstable stream banks by 9% over two grazing seasons as compared to pastures not offering supplemental feed/salt (McInnis and McIver 2001).
- Reduced time cattle spent near stream by 50-100% (Dolev et al. 2010).

2.1.9. Mortality Management

- Description. The proper disposal of animal mortality.
- Benefits to producer. Proper management of animal mortality can provide the following benefits:
  - Reduces pollution of groundwater and surface water.
  - Reduces odors from improperly handled carcasses.
  - Reduces damage to crops and forages.
  - Decreases risk of diseases spreading to animals feeding on the carcass.
  - Provides contingencies for normal and catastrophic mortality events.
- Bacterial removal efficiency. Most studies on pathogen reduction and mortality management have focused on composting and incineration. The key is to maintain temperatures high enough to eliminate pathogens. Composting

controls nearly all pathogenic viruses, bacteria, fungi, and protozoa (Wilkinson 2007). Bin and static pile composting systems can dramatically reduce bacteria levels. A study by Mukhtar et al. (2003) found levels of *Salmonella* and fecal coliform bacteria were almost undetectable after nine months even with little maintenance of the piles. The study concluded that a low-maintenance bin-composting operation can successfully dispose of livestock carcasses and bedding in temperate climates during seasons of normal precipitation.

- Estimated installation costs. This will depend on the method chosen to manage mortality. For burial, rental of backhoe, if necessary, will cost approximately $100-$200. To dispose of animal at a sanitary landfill, the cost is approximately $80-$150. Incineration of a 1,000 pound animal can cost from $600 to $1,000 depending on the location and current price of fuel. The cost of composting a whole animal is approximately $4 per carcass (Looper 2007). Finally, the cost of rendering is approximately $25 to $200 per animal.

2.1.10. Pesticide Management

- Description: This practice involves implementing various management practices to limit agricultural pests and to reduce potential adverse effects on plant growth, crop and forage production, and the environment (NRCS 2012). This practice seeks to control agricultural pests rather than eliminate them.
- Benefits to Producer. Pesticide management can provide the following benefits:

    - Decreased reliance on chemical pest control methods.
    - Reduced contamination of groundwater and surface water sources.
    - Maximize economic returns.
    - Enhance quality of agricultural commodities.
- Bacterial removal efficiency. This practice is often used in conjunction with other practices including exclusionary fencing, prescribed grazing, and heavy use area protection, which have been shown to reduce bacterial contamination of surface water sources.
- Estimated installation costs. The NRCS estimates this practice to cost \$10/acre to \$18.58/acre depending on the conditions of the operation. These estimates include costs for scouting, mitigation, and fuel.

2.1.11. Prescribed Grazing

- Description. The controlled harvest of vegetation with grazing or browsing animals, managed with the intent to achieve a specified objective. This practice employs utilization of grazing management principles that define stocking rate; rest periods; and intensity, frequency, duration, and season of grazing to promote ecologically and economically stable plant communities that meet both the land manager's objectives and resource needs. Moderate stocking has been shown to not significantly increase *E. coli* levels above background levels and provide additional benefits to producers. This, in combination with deferred grazing on creek pastures during rainy periods and use of other practices can significantly reduce bacterial runoff (Wagner et al. 2012).

- Benefits to producer. Prescribed grazing can provide the following benefits:
    - Greater distribution of grazing and utilization of forage.
    - Reduces supplemental feed costs.
    - Improves property aesthetics and increases property value.
    - Improves water quality by reducing sediment, nutrient, bacterial, organic, and inorganic loading to the stream.
    - Reduces stream bank destabilization and associated erosion due to trampling and overgrazing of banks.
    - Improved health and vigor of desired plants to maintain a stable plant community.
    - Provides and maintains food, cover, and shelter for wildlife.
    - Maintains and improves surface and/or subsurface water quantity and quality.
    - Reduces accelerated soil erosion and maintains or improves soil condition.
    - Improves or maintains animal health and productivity by providing better quantity and quality of forage for grazing.
    - Allows for regeneration of riparian zone vegetation to act as a full or partial buffer.

- Bacterial removal efficiency**.** Prescribed grazing resulted in the following bacterial reductions:
    - *E. coli:*
        - 72% reduction (from 177.6 cfu/100mL to 103.5 cfu/100mL) with use of prescribed grazing on 152 acres and when combined with other practices including contour farming, grassed waterways, nutrient management, and pest management (EPA 2010).
        - 67-85% reductions in *E. coli* levels may be achieved by converting from heavy to moderate stocking rates (Wagner et al. 2012).
        - 66% (from 1250 cfu/100mL to 425 cfu/100mL) when intensity of grazing was changed from heavy (1.9 aum/ha) to moderate (0.8 aum/ha) over a 7-month period (Tate et al. 2004).
    - Fecal coliform:
        - 96% reduction (from 92 cfu/100mL to 4.0 cfu/100mL) when intensity of grazing was changed from heavy to no grazing (Tiedemann et al. 1988).
        - 90% reduction (from 30.2 cfu/100mL to 2.9 cfu/100mL) when intensity of grazing was changed from heavy to no grazing (Tiedemann et al. 1987).
- Additional benefits**:** The use of prescribed grazing resulted in the following additional benefits:
    - Increased potential for ranch profits (Richards and George 1996).

- Reduced suspended sediment by 8% and nitrogen loads by 34% when combined with other practices (Portneuf SWCD 2008).
- Runoff from a heavily grazed pasture (1.35 AUM/acre) was 1.4 times greater than from a moderately grazed pasture (2.42 AUM/acre), and 9 times greater than from a lightly grazed pasture (3.25 AUM/acre) (Kaufmann and Krueger 1984).
- Increased fish production by 184% where livestock use was light (Bowers et al. 1979).
- Reduced soil compaction under light to moderate grazing intensities (Tate et al. 2004).
- Increased infiltration, runoff attenuation, and soil moisture retention when appropriate rest periods are utilized (Ratliff et al. 1972).
- Enhanced herbaceous plant diversity (Marty 2005).
- Control of noxious weeds (DiTomaso 2000, Frost and Launchbaugh 2003).

2.1.12. Shade Structure

- Description. A permanent or portable framed structure to provide shade for livestock, improve distribution of grazing, and provide alternative shade location to that found in the riparian area.
- Benefits to producer. Shade structures can result in the following benefits:
    - Improves animal health and well-being.

    - Reduces time cattle spend in or near waterway thereby reducing stream bank erosion and protecting riparian area.
    - Reduces manure deposition and associated bacterial contamination of surface waters.
- Bacterial removal efficiency. Shade structures resulted in an 85% reduction in *E. coli* when combined with an off-stream watering source (Franklin et al. 2009).
- Additional benefits. The use of shade structures resulted in the following benefits:
    - Average 27% reduction in time spent loafing in riparian zone (Clary 2012)
    - Increased weight of 1.25 lbs/day for cows, 0.41 lbs/day for calves, and 0.89 lbs/day for steers when provided shade in the spring and summer (Turner 2000).
    - Reduced deep body temperatures of cattle by 0.5°-1.4°F (Turner 2000)
    - Increased summer gain of yearling Hereford steers by 19 lbs/head in a 4-year study (McIlvain and Shoop 1970).
    - Reduction in cow's radiant heat load by 30% (Bond et al. 1967).
    - Reduction in total suspended solids and total phosphorus with availability of non-riparian shade (Byers et al. 2005).
    - Improved grazing distribution (McIlvain and Shoop 1970).

- Estimated installation costs. The NRCS estimates installation costs to be $6.50/square foot.

2.1.13. Soil Testing and Nutrient Management

- Description. Manages the amount, source, placement, form, and timing of the application of nutrients and soil amendments.
- Benefits to producer. Soil testing can provide the following benefits:
    - Allows producer to take advantage of nutrients already in the soil.
    - Identifies nutrients lacking in the soil.
    - Reduces fertilizer applications by applying only what is needed.
    - Provides a proper balance of plant nutrients.
    - Adjusts soil pH to an optimum level.
    - Reduces chances of excess nutrients getting into water sources.
    - Saves money by applying only the amount of fertilizer and organic by-products necessary.
- Bacterial removal efficiency. Using soil testing and nutrient management practices on your farm or ranch will help minimize bacterial contamination of waterways by ensuring the proper amount of manure is applied at the appropriate time. This BMP also helps reduce nutrient contamination, which causes algae blooms and eutrophication (low dissolved oxygen in water). Without laboratory analyses of your soil and manure, it is impossible to know the nutrient requirements of your soil and the nutrient and bacterial

composition of your manure. Thus, the over-application of manure becomes a real concern.

- Estimated installation costs. A routine soil analysis can be obtained for as little as $10 per sample from the Texas A&M AgriLife Extension Service Soil, Water, and Forage Testing Laboratory at Texas A&M University. The laboratory also does other soil analyses. A manure analysis costs $15 per sample. This test analyzes levels of calcium, copper, magnesium, manganese, nitrogen, phosphorus, potassium, sodium, zinc, and percent moisture.

2.1.14. Stream Bank and Shoreline Protection

- Description: This practice involves stabilizing stream banks, shorelines, and constructed channels as well as shorelines of lakes, reservoirs, and estuaries to prevent soil degradation and erosion (NRCS 2012).
- Benefits to producer: Stream bank and shorelines protection can provide the following benefits:
    - Reduces accelerated soil erosion and maintains or improves soil condition.
    - Improves aesthetic appearance of land.
    - Reduces herd health risks associated with livestock standing in muddy areas, such as foot disease and injuries due to unstable footing.
- Bacterial removal efficiency. This practice is often used with heavy use area protection, which has been shown to result in a 92%-99% reduction in fecal

coliform with use of mulch, straw, and seed on high use areas (Lennox et al. 2007).

- Estimated installation costs. The NRCS estimates this practice to cost between $1.21/square foot to nearly $3,000 depending on the method of stream bank stabilization used. For example, the choice between a general vegetative cover, rip-rap, or rock barbs will cause the cost to vary dramatically.

2.1.15. Stream Crossing

- Description. A stabilized area or structure constructed across a stream to provide a travel way for people, livestock, equipment, or vehicles.
- Benefits to producer: A stream crossing may provide the following benefits:
    - Reduces herd health risks associated with livestock standing in muddy areas, such as foot disease and injuries due to unstable footing.
    - Improves water quality by reducing sediment, nutrient, bacterial, organic, and inorganic loading to the stream.
    - Decreases herd injuries associated with cattle climbing steep and unstable stream banks.
    - Provides livestock access to all pastures.
    - Discourages cattle from congregating or wallowing in the stream.
- Bacterial removal efficiency: Stream crossings resulted in the following bacterial reductions:
    - *E. coli:*

        - 46% average reduction when combined with other practices (riparian fencing, alternative water supplies, and stream bank bioengineering; Meals 2001).
    - Fecal coliform:
        - 52% average reduction when combined with other practices (riparian fencing, alternative water supplies, and stream bank bioengineering; Meals 2001).
        - 44% average reduction when combined with other practices (manure storage facilities, fencing, watering troughs, nutrient management, conservation tillage, and grassed waterways; Inamdar et al. 2002).
    - Fecal streptococci:
        - 51% average reduction when combined with other practices (riparian fencing, alternative water supplies, and stream bank bioengineering; Meals 2001).
        - 46%-76% average reduction when combined with other practices (manure storage facilities, fencing, watering troughs, nutrient management, conservation tillage, and grassed waterways; Inamdar et al. 2002).
- <u>Additional benefits</u>: The use of stream crossings resulted in the following benefits:

- When combined with other practices, decreased total phosphorus, total nitrogen, and total suspended solid concentrations by 18-25% (Meals 2001).
- Reduced baseflow phosphorus levels by as much as 38% (Rao et al. 2009).
- When combined with other practices, reduced nitrate nitrogen concentrations by 35% and particulate phosphorus concentrations by 78% (Brannan et al. 2000).

- Estimated installation costs. The NRCS estimates installation costs to be approximately \$60.88/cubic yard to \$325.00/cubic yard depending on material used for crossing (rock or concrete).

2.1.16. Watering Facility

- Description**.** A permanent or portable off-stream water supply, such as a trough or pond system, that provides an adequate amount and quality of drinking water for livestock and/or wildlife and also helps improve animal distribution.
- Benefits to producer. A watering facility can provide the following benefits:
    - Reduces herd health risks associated with livestock standing in muddy areas, such as foot disease and injuries due to unstable footing.
    - Provides clean source of water for livestock.
    - Decreases herd injuries associated with cattle climbing steep and unstable stream banks.

    - Improves water quality by reducing sediment, nutrient, bacterial, organic, and inorganic loading to the stream.
    - Reduces stream bank destabilization and associated erosion due to trampling and overgrazing of banks.
    - During drought, when surface water sources are dry, an alternative water source provides the water necessary for beef cattle producers to remain in business.
- <u>Bacterial removal efficiency</u>*:* An off-stream alternative water supply resulted in the following bacterial reductions:
    - Fecal coliform:
        - 51%-94% when combined with fencing (Hagedorn et al. 1999, Sheffield et al. 1997).
    - *E. coli*:
        - 85% (Byers et al. 2005).
    - Fecal streptococci:
        - 77% (Sheffield et al. 1997).
- <u>Additional benefits</u>*:* An off-stream alternative water supply resulted in the following benefits:
    - Reduction in the amount of direct livestock use of stream for drinking and other activities by:
    - 43%-90% (Wagner et al. 2013, Sheffield et al. 1997, Franklin et al. 2009, Godwin and Miner 1996, Brown 2006, Clawson 1993, Miner et al. 1992).

    - Reduction in stream bank erosion by 77% (Sheffield et al. 1997).
    - Increased gain in beef cattle of 0.2-0.4 lb/day (Willms et al. 1994, Buchanan 1996, Porath et al. 2002, Veira 2003, Willms et al. 2002, Dickard 1998).
    - Improved milk and butterfat production in dairy cattle (Bendfeldt 2004, Landefeld and Bettinger 2002, Zeckoski et al. 2007).
    - Increased annual net returns to ranch between $4,500 and $11,000 depending on cattle prices and precipitation levels with use of off-stream salt supplements (Stillings et al. 2003).
    - Increased annual grazing capacity by 85 AUMs (Workman and Hooper 1968).
- <u>Estimated installation costs</u>. The NRCS estimates installation costs to be:
    - Watering troughs: $450 to about $7,600 depending on the size and material (plastic, galvanized metal, fiberglass, or concrete).
    - Electric water pumps: $1,900 to $4,000 depending on the size.
    - Solar water pumps: $5,700 to $12,000 depending on well depth.
    - Windmills: $8,200 to $17,800 depending on fan diameter.
    - Pond: $2.08/cubic yard to $10.08/cubic yard depending on size.

2.2. Factors Influencing Adoption of BMPs in the Agricultural Sector

Despite technical and financial assistance through government programs and known water quality benefits, the literature reveals BMP adoption rates are low (Gillespie et al. 2007). Cary et al. (2001) suggested a wide range of barriers exist to discourage the adoption of conservation practices and these constraints are related to the "perspective of individual landholders, the characteristics of desirable management practices, the socioeconomic structure of adopters' communities, and the broader institutional settings" (2001, 4). Ervin and Ervin (1982) identified personal, physical, economic, and institutional constraints as key factors in the adoption decision process of individuals. Guerin (1999) suggested a multi-factorial problem whereby personal attributes associated with the landowner as well as characteristics of the innovation play a role in the adoption decision. In their meta- analysis of BMP adoption studies, Prokopy et al. (2008) defined capacity, attitudes, environmental awareness, and farm characteristics as major factors in explaining adoption. Lastly, Nowak (1992) differentiates between two types of barriers to adoption:

Barriers related to an individual's inability to adopt: (1) Information lacking or scarce; (2) costs of obtaining information too high; (3) complexity of the system too great; (4) too expensive; (5) labor requirements excessive; (6) planning horizon too short (benefits too far in the future); (7) limited availability and accessibility of supporting resources; (8) inadequate managerial skill; and (9) little or no control over the adoption decision.

Barriers related to an individual's unwillingness to adopt: (1) Information conflicts or inconsistency; (2) poor applicability and relevance of information; (3) conflicts between current production goals and the new technology; (4) ignorance on the part of the farmer or promoter of the technology; (5) inappropriate for the physical setting; (6) increased risk of negative outcomes; and (7) belief in traditional practices.

Clearly, the decision to adopt a conservation practice is a complex one and can be affected by a wide variety of constraints and barriers (Ervin and Ervin 1982, Westra and Olson 1997). This section will detail relevant barriers supported by the literature to provide a focal point for this particular study. The categories suggested by Prokopy et al. (2008) will be used as the foundation for this section.

2.2.1. Capacity

According to Carpenter et al. (2001), capacity is the ability of a system to maintain function and control while undergoing disturbance or change. In this study, capacity will be considered as the collective factors that increase a farmer's ability to adopt a BMP (Table 2.1).

Table 2.1
Collective variables describing the capacity construct (adapted from Prokopy et al. 2008).

Capacity Variables	**Description**
Age	Farmer age
Diversity	Measures that can capture diversity of farm operation
Education	Farmer education or previous training
Farming experience	Years farming
Income	Measures of wealth such as income, crop value, etc.
Information	Access to and quality of information
Labor	Measures of increased labor available to the farm
Networking	Overall measure of networking capacity

The age of a farmer has been shown to influence adoption decisions, however, the literature appears inconsistent as to whether the influence is positive or negative. For example, age has been shown to be negatively correlated with adoption (Featherstone and Goodwin 1993, Soule et al. 2000), positively correlated (Harper et al. 1990, Kim et al. 2005, Petrzelka et al. 1996), and insignificantly correlated (Daberkow and McBride 2003, McCann et al. 1997). In the studies showing negative correlation between age and adoption, the overarching explanation is that older producers typically have shorter planning horizons and, therefore, may find it difficult to comprehend the long-term benefits of adoption. As a consequence, younger producers tend to be more willing to innovate (Daberkow and McBride 2003). Conversely, studies showing positive correlations between age and adoption suggest that older producers more heavily weigh the meaning of maintaining and conserving the land (Basarir 2002). As such, protection of natural resources becomes much more important than economics as a producer ages. In addition, older producers tend to have more experience with a wide range of BMPs and are, therefore, more likely to adopt them (Le and Beaulieu 2005).

The income level of a farmer has been shown to affect the adoption rates of conservation practices. Farmers with higher levels of income can afford to invest in new technologies and innovations as compared to farmers with lower income levels (Gould et al. 1989). In addition, higher income farmers benefit from tax incentives that low income farmers might not be eligible for (Norris and Batie 1987). Income can come from on-farm or off-farm sources. Mishra et al. (2002) report 71% of US farm households receive income from off-farm employment mainly to offset the variability associated with on-farm income (Huffman 1980, Barlett 1986, Loftus and Kraft 2003). Although much of the literature suggests a positive correlation between income and adoption, Núñez (2005) found farmers receiving income from off-farm employment didn’t have enough time to adopt new technologies. Gedikoglu et al. (2011) found off-farm work had positive impacts on the adoption of capital-intensive practices (e.g. manure injection of soil) and negative impacts on labor-intensive practices (e.g. record-keeping).

The level of diversity of an operation can influence adoption rates. As farm acreage increases, diversity may also increase. Research suggests producers with diverse operations are more likely to experiment with new innovations and that this diversity qualifies the landscape for a wider variety of BMPs (Rahelizatavo and Gillespie 2004). Abd-Ella et al. (1981) suggested, however, that diversity can negatively impact adoption rates as access to a wider variety of BMPs can limit the amount of time a producer has to research each practice and make an effective decision on which one(s) to implement.

The education level of a producer can affect adoption rates (Caswell et al. 2001, Gould et al. 1989, Kim et al. 2005, Park and Lohr 2005). Research suggests more highly educated producers are able to make better-informed decisions and are more likely to be aware of alternatives available to them in their operation (Kim et al. 2005). Wu and Babcock (1998) found increased education was positively correlated with the adoption of reduced tillage practices. Regarding traditional university education, Weinkauf (2008) argued for the need to consider the type of degree earned and the school attended rather than just the amount of time spent at an educational institution. Beyond the education received at a traditional school or university, education can also be obtained from workshops, field days, demonstrations, and other events. Harper et al. (1990) found attendance at field days to significantly affect BMP adoption rates. Caswell et al. (2001) suggested a producer’s willingness to obtain additional education off-site had a positive influence on their decision to adopt management intensive conservation practices. In addition, Loftus and Kraft (2003) found farmers who gained education from frequent visits with county extension agents were more likely to enroll land into government conservation programs. Despite the positive correlations between education and adoption found in the majority of studies, Welch (1978) cautioned additional education may actually increase the cost of applying a new technology or innovation and, therefore, reduce its adoption, if advanced technical skills are deemed necessary.

Closely related to education is the role information plays in the adoption of conservation technologies. The availability and accessibility of information related to BMPs is critical to securing their adoption (Traoré et al. 1998, Alonge and Martin 1995). Baide (2005) found producers still lack knowledge concerning the benefits and implementation requirements of BMPs and this lack of information is a major barrier to the adoption of conservation practices. Saltiel et al. (1994, 334) found access to information "plays a stronger role in the adoption of management-intensive practices than it does for low-input methods." In another study, access to information had a stronger impact on adoption rates than did attitudes on producer behavior (Petrzelka et al. 1996). In addition, the source of information has been found to influence adoption rates of conservation practices (Daberkow and McBride 2003). Research suggests the effort expended by producers to gain information about a practice is directly related to the benefit they expect to gain from implementation of that practice (Feder et al. 1985). Access to information, however, may not always result in beneficial environmental protection (Stoneman and David 1986).

Avenues that can increase access to information are the networking channels between producer and agency personnel, other members of the agricultural sector, and neighbors (Prokopy et al. 2008). Research suggests that when exposed to the ideas of others through networking opportunities, adoption of practices is likely to increase (Belknap and Saupe 1988, Norris and Batie 1987, Prokopy et al. 2008). Westra and Olson (1997) found producers who relied on other producers for information about a particular tillage practice were more likely to adopt the practice. In addition, membership in local groups can positively influence the adoption of conservation practices (Burton et al. 1999).

Farming experience can either negatively or positively influence the adoption decisions of livestock producers (Caswell et al. 2001). Producers with many years of experience are often better equipped at incorporating new technologies into production because of their increased expertise. In addition, as experience increases, producers better understand the consequences of environmental degradation and the value of the conservation practice (Tosakana et al. 2010). On the other hand, those with substantial experience and time in the business may be more reluctant to change technologies, especially if the new technologies are counter to what they've been doing for a number of years. Some research suggests that experience with new innovations is highly correlated with increased education, but not necessarily with age (Huffman and Mercier 1991). This is related to the previously discussed finding that older producers tend to have shorter time horizons and, therefore, struggle with seeing the long-term benefits of a conservation practice.

2.2.2. Attitudes

Ajzen (1988, 4) defined attitude as “a disposition to respond favorably or unfavorably to an object, person, institution, or event.” Attitudes alone are not necessarily a strong predictor of the behavioral intentions of an individual, but when examined with subjective norms and behavioral control, can be a very effective predictor (e.g. the theory of planned behavior will be discussed in the next chapter; Prokopy et al. 2008). The collective variables describing the attitudes influencing a producer’s decision to adopt a BMP are listed in Table 2.2.

Table 2.2
Collective variables describing the attitude construct (adapted from Prokopy et al. 2008).

Attitude Variables	**Description**
Overall attitude	The attitude category as a whole
Adoption payments	Farmer receiving payments for implementing BMPs
Profitability of practice	Thinks practice will lead to profit
Heritage	Farm will be taken over by a family member
Risk	A measure of willingness to take risks

Whether or not a producer is receiving cost-sharing from government programs has been shown to influence adoption rates of BMPs (Weinkauf 2008). A report conducted by the US Government Accountability Office in 2006 cited lack of adequate cost-sharing funds as the main reason for non-adoption of BMPs. It has been suggested by Featherstone and Goodwin (1993) that if a producer is already receiving financial incentive payments, they naturally have more information about the program and practice as compared to someone not receiving payments. As a result, the more likely it will be for them to participate in additional programs that assist them in implementing

BMPs in the long-term. Napier et al. (2000), however, found a negative correlation between financial assistance programs and BMP adoption stating, “Either the farmers within the study watersheds are so affluent that they do not need financial support from government sources or the amount of government financial assistance received is so small and confined to such a small number of land owner operators that investment of public funds has had little positive impact on adoption of conservation production systems at the farm-level” (Napier et al. 2000, 134). In another study that compared one watershed receiving assistance from a variety of local, state, and federal sources to another watershed receiving no assistance, Napier and Bridges (2002) found no differences in adoption rates between the two watersheds.

The perceived profitability of a conservation practice can impact adoption (Cary and Wilkinson 2008, Prokopy et al. 2008). If a producer perceives a particular practice to be profitable prior to adoption, the more likely he will be to adopt that particular practice (Napier et al. 2000, Roberts et al. 2004). In one of the first studies to evaluate factors that affect adoption rates, Griliches (1957) found profitability was the largest determinant of adoption. Gedikoglu et al. (2011) also found profitability to be the most important factor impacting adoption of a manure handling system. The perceived profitability of a practice is more important for profit-oriented practices than for environment-oriented practices (Gedikoglu and McCann 2012) and in the absence of additional incentives, will play a major role in the adoption of a practice (Knowler and Bradshaw 2007). Barr and Cary (2000) suggested the profitability and attractiveness of various practices will differ across space and time.

Research suggests the adoption of conservation practices will increase when a farm or operation stays in a family for a long period of time (Ervin and Ervin 1982, Norris and Batie 1987, Kim et al. 2005, Prokopy et al. 2008). Having a long-range plan for the operation in terms of ownership can help increase the planning horizon and, therefore, make it easier for a producer to comprehend the long-term benefits of implementing a conservation practice (Kim et al. 2005).

Finally, risk and uncertainty can affect adoption rates and have been addressed in previous research studies (Feder 1980). In particular, risk refers to the uncertainty that a producer might face regarding the benefits, costs, overall effectiveness, and timing of effectiveness (Cary et al. 2001). Whether the risk associated with implementation of a practice is real or perceived, research suggests the risk of a negative outcome or increased uncertainty regarding a practice can be a substantial barrier to adoption (Baide 2005). Ervin and Ervin (1982) argued as risk aversion increases, adoption of conservation practices decreases. Producers may face greater risks for some practices than they will for others (Weinkauf 2008). Rahelizatovo (2002) suggests producers can reduce their risk by acquiring additional information about a practice. For innovations high in risk or uncertainty, Vanclay and Lawrence (1993) argue social influences from neighbors will play a greater role in the adoption process. In addition, producers who avoid substantial amounts of risk typically choose to adopt practices that increase net returns (Kim et al. 2005).

2.2.3. Environmental Awareness

Attitudes and awareness are intricately linked. Forsyth et al. (2004) utilized the phrase "appraisal" to suggest an awareness of an issue is the first step in developing an attitude about the issue. Regarding environmental issues, Kaiser et al. (1999) argued awareness of the issue precedes development of an attitude about the issue, but more importantly, understanding how a behavior can be carried out is often more important than awareness alone. The collective variables describing environmental awareness influencing a producer's decision to adopt a BMP are listed in Table 2.3.

Table 2.3
Collective variables describing the environmental awareness construct (adapted from Prokopy et al. 2008).

Awareness Variables	Description
Overall awareness	The environmental awareness category as a whole
Environmental attitudes	Importance individual places on environmental quality
Cause	Understanding how agriculture can impact water quality
Quality of environment	Farmer's awareness of the current quality of the environment
Consequences	Understanding the consequences of a degraded system
Knowledge	Knowledge of general terms or facts related to water quality
Program	Knowledge of nonpoint source programs or efforts

Farmers and ranchers have traditionally been characterized as having a deep awareness of natural cycles and a sense of responsibility toward protecting the surrounding environment (McCann et al. 1997). Research suggests that because farmers and ranchers depend on their land for their livelihood, they naturally possess a higher environmental awareness and are, therefore, more likely to adopt BMPs to protect the resources contained on their land (McCann et al. 1997). Napier et al. (1988) found an awareness of problems related to soil erosion was highly correlated to the adoption of practices designed to correct such problems. Research suggests the environmental awareness of a producer can be increased with increased levels of educational attainment, membership in producers' organizations, and participation in government financial assistance programs (Traoré et al. 1998).

The awareness an individual has concerning their surrounding environment and the importance they place on environmental quality can affect adoption rates of conservation practices. If producers are not aware an environmental problem exists, they will not be highly motivated to adopt practices intended to enhance environmental protection (Napier and Napier 1991). Furthermore, water and soil degradation won't be reversed until land operators develop a strong environmental ethic (Napier and Napier 1991). Individuals who perceive local water quality to be poor are more likely to adopt a practice to help improve water quality due to a personal sense of obligation (Ervin and Ervin 1982). Korsching and Nowak (1983) cautioned, however, that producers often greatly overestimate their conservation effort. A study conducted by Smith et al. (2007) concluded while producers believed BMPs to be effective and environmental resources were worth protecting, producers did not readily know that their surrounding waters were impaired. The authors link low adoption rates to the gap between perceived levels of water quality degradation and actual levels of degradation. It has been shown producers consistently underestimate the severity of environmental degradation on their own land (Bruening and Rollins 1990, Napier et al. 1988) and awareness is often spatially selective meaning farmers are more often aware of their neighbor's erosion problem than they are of their own (Smithers and Smit 1989). Awareness is more than knowing a problem exists, however. An individual must also be aware of existing approaches to solve the environmental problem (Napier and Napier 1991).

The awareness an individual has concerning their role in environmental degradation can influence adoption of BMPs. Napier and Napier (1991) argued for producers to adopt new technologies, they must be aware of the role they play in environmental degradation and that alternative solutions exist. In a survey of Texas citizens, approximately 50% of all respondents marked “I don’t know” when asked about conditions and activities that affected water quality (Boellstorff et al. 2010). This evidence confirms an enormous level of disconnect exists between the average Texas citizen and their potential impact on water quality. With that said, Cary and Wilkinson (2008) cautioned that even if awareness of the environmental problem is lacking, implementation may still occur due to the practice being technically feasible and economically viable to implement. Clearfield and Osgood (1986) suggested, however, that even if a producer has a strong conservation awareness, implementation of a practice may still not occur due to financial limitations, lack of information, or other constraints.

The level of awareness a producer has about general terms or facts related to environmental quality as well as nonpoint source control programs can influence adoption rates of conservation practices. Rahelizatovo (2002) found a major barrier to adoption was the lack of information producers had regarding legislation and efforts to control nonpoint source pollution through the use of BMPs and other programs.

Obubuafo et al. (2008) linked farm size to awareness of government financial incentive programs and found small, cow-calf operations were less aware of programs such as EQIP.

2.2.4. Farm Characteristics

The characteristics of a farm or operation can influence whether or not a landowner adopts conservation practices. Table 2.4 presents the collective variables describing the various farm characteristics that can influence a producer's decision to adopt a BMP.

Table 2.4
Collective variables describing the farm characteristic construct (adapted from Prokopy et al. 2008).

Farm Characteristic Variables	**Description**
Acres	Total acres included in operation
Applicability/compatibility	Applicability and compatibility of practice to landscape
Capital	Measure of investment into farm (excluding acres)
Land tenure	Whether operator owns farmland
Operator gender	Primary operator is male
Ownership type	Individually owned versus corporate-owned farms
River	Farm located near a stream or in a river bottom

The investment an individual has into a farm (i.e. capital) is also expected to positively influence adoption rates (Prokopy et al. 2008). Producers with more land may have more financial capital (Kaufman 2011) and access to capital provides the economic capacity to adopt conservation practices (Napier et al. 1984). Conversely, producers with a high debt to asset ratio and, therefore, lower capital, lack the capacity to adopt conservation practices and will, out of necessity, focus on production rather than conservation (Ervin and Ervin 1982). Included in the discussion of capital is the amount of acreage contained within the operation. Research suggests increased acreage is positively correlated with adoption as larger farms have greater economies of scale (Prokopy et al. 2008, Belknap and Saupe 1988, Caswell et al. 2001). Caswell et al. (2001) suggested larger farms have higher adoption rates because they often have lower management costs per unit of output and can spread equipment costs over larger areas (Lee and Stewart 1983). However, there is much debate in the literature regarding the influence of farm size on adoption rates (Prokopy et al. 2008). Agunga (1995) found small-scale operators have higher adoption rates because they have more time to evaluate the risks involved as compared to producers with more acreage. With that being said, a technology requiring significant financial investment is less likely to be adopted by a small-scale producer simply based on economies of scale (Wandel and Smithers 2000).

In addition to total acreage, whether or not the producer owns or rents his or her land has been shown to influence adoption rates of conservation practices. Land tenure has been found to be negatively correlated with adoption (e.g. Caswell et al. 2001, Khanna 2001), positively correlated with adoption (Belknap and Saupe 1988, Daberkow and McBride 2003, Kim et al. 2005), and not significantly correlated with adoption (Bosch et al. 1995, Lynne et al. 1988). The relationship between land tenure and adoption rates is complex and not fully understood (Weinkauf 2008). Caswell et al. (2001) suggest land ownership will increase adoption because the landowner will directly benefit from the practice. In addition, producers who own land are traditionally viewed as being better stewards of the environment as compared to those who rent (Caswell et al. 2001). Lee and Stewart (1983) found producers who owned small acreages had lower minimum tillage adoption rates as compared to those with larger holdings. Other research suggests that producers who both own and rent land are more likely to implement conservation practices only on the land they own (Esseks and Kraft 1989, Soule et al. 2000). Tied to land tenure is ownership type. Operations owned by individuals are more likely to adopt BMPs than operations owned by corporations because individual owners possess greater management flexibility (Park and Lohr 2005).

The location of a farm near a water body can influence an individual's awareness concerning water quality as well as their desire to implement conservation practices to protect water quality (Gillespie et al. 2007). Rahelitazovo (2002) evaluated the impacts of location relative to a water body on the adoption of dairy BMPs and found a positive correlation. Nyaupane and Gillespie (2009), however, found that having a stream running through an operation negatively influenced the adoption of conservation practices.

The applicability or compatibility of a practice to a particular landscape or operation can affect adoption rates (Alonge and Martin 1996, Westra and Olson 1997). Rogers (2003, 15) defined compatibility as "the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters." For example, a conservation practice designed to reduce gully erosion would not be applicable on a landscape that didn't have gully erosion. Likewise, a practice designed to slow runoff coming from a steeply sloped area would not be applicable on flat ground. Rahelizatovo (2002) found a high percentage of respondents suggested non-applicability of BMPs to their farm, which greatly reduced the adoption of those BMPs. Lack of information regarding a practice can result in the producer believing that a practice is not applicable or even necessary on their operation. In addition, the "free rider" problem may also be a factor if producers view their conservation action as minor in the collective effort.

The role that gender plays in the adoption of conservation practices has been investigated in previous studies. Some research suggests that women have stronger environmental ethics as compared to men and are, therefore, more likely to adopt conservation practices (Zelezny et al. 2000). Ghazalian et al. (2009) suggest women are more concerned with the health of their family and are, therefore, more motivated to adopt BMPs. In rural locations, however, some research has proven women tend to have lower education levels as compared to men and therefore have less access to information regarding the benefits of BMPs (Lubwama 1999). This negatively impacts their motivations to adopt conservation practices. Bayard et al. (2006) suggest that men are more likely to implement labor-intensive practices as these are seen as a "man's job." Women, on the other hand, will implement labor-intensive practices provided they have the financial resources to hire labor (Bayard et al. 2006).

2.3. New Ecological Paradigm

An individual's inherent environmental orientation and ethic can greatly influence their perspective on environmental degradation and their view on the proper course to correcting degradation. Those possessing an anthropocentric, or humanocentric, viewpoint believe humans are the superior being. As such, followers of this philosophy hold environmental exploitation higher than environmental conservation to further human progress. Humanocentrics view environmental degradation as a technical problem that can be combated with increased consumption and production (Rahelizatovo 2002). In contrast to an anthropocentric worldview is a "deep ecology" worldview proposed by Naess (1973). Deep ecologists believe the living environment, in addition to the human environment, has the same right to flourish. They recognize the limits of growth and natural resources as well as the fragility of nature's balance (Rahelizatovo 2002). Deep ecologists view environmental degradation as a negative consequence of human's domination on the landscape and view conservation efforts as a necessary means to lessen the harmful effects that humans have on the environment.

In an effort to measure an individuals' environmental philosophy and orientation, Dunlap et al. (1978 and 2000) created and refined the New Ecological Paradigm (NEP) scale. The original scale consisted of 12 items that focused "on beliefs about humanity's ability to upset the balance of nature, the existence of limits to growth for human societies, and humanity's right to rule over the rest of nature" (Dunlap et al. 2000, 427). A serious flaw of the original scale was that "only four of the 12 items were worded in an anti-NEP direction, and all four focused on anthropocentrism or the belief that nature exists primarily for human use and has no inherent value of its own" (Dunlap et al. 2000, 427). Due to this imbalance, Dunlap et al. (2000) revised the 12-item scale to include 15 items (Table 2.5); three items each measure five hypothesized facets of an ecological worldview: the reality of limits to growth (Questions 1, 6, 11), antianthropocentrism

Table 2.5
The revised New Ecological Paradigm (NEP) scale (Dunlap et al. 2000).

Statement
1. We are approaching the limit of the number of people the earth can support.
2. Humans have the right to modify the natural environment to suit their needs.
3. When humans interfere with nature it often produces disastrous consequences.
4. Human ingenuity will insure that we do NOT make the earth unlivable.
5. Humans are severely abusing the environment.
6. The earth has plenty of natural resources if we just learn how to develop them.
7. Plants and animals have as much right as humans to exist.
8. The balance of nature is strong enough to cope with the impacts of modern industrial nations.
9. Despite our special abilities, humans are still subject to the laws of nature.
10. The so-called "ecological crisis" facing humankind has been greatly exaggerated.
11. The earth is like a spaceship with very limited room and resources.
12. Humans were meant to rule over the rest of nature.
13. The balance of nature is very delicate and easily upset.
14. Humans will eventually learn enough about how nature works to be able to control it.
15. If things continue on their present course, we will soon experience a major ecological catastrophe.

(Questions 2, 7, 12), the fragility of nature's imbalance (Questions 3, 8, 13), rejection of exceptionalism (Questions 4, 9, 14), and the possibility of an ecocrisis (Questions 5, 10, 15). The revised 15-item scale is known as the New Ecological Paradigm (NEP) Scale. 15). Each question is worded so agreement with the odd-numbered questions and disagreement with the even-numbered questions denotes a pro-ecological view.

Several studies have been conducted to determine the validity and reliability of the NEP scale (Edgell and Nowell 1989, Pierce et al. 1992, Widegren 1998, Dunlap et al. 2000). Furthermore, these studies have examined a range of population sectors including farmers (Albrecht et al. 1982), interest groups (Edgell and Nowell 1989), ethnic minorities (Caron 1989), and international citizens (Edgell and Nowell 1989). Overwhelmingly, the scale has been proven to accurately predict the environmental attitude of an individual. The studies of interest groups suggest environmentalists score higher on the NEP scale than do non-environmentalists suggesting group validity. Also, several studies have shown the strength of the NEP scale in predicting behavior from general attitudes and beliefs suggesting predictive validity as well (Dunlap et al. 2000). For example, Stern (2000) used a variation of the NEP to explain the propensity toward behaviors that had beneficial impacts on the environment. He suggests this understanding can provide useful input to programs designed to protect the environment. Thapa (1999) used the NEP scale to determine environmentalism among undergraduate students and its relation to responsible environmental behaviors. He found an attitude-behavior link suggesting an environmentally sympathetic perspective can sometimes translate into environmentally-friendly behaviors. Kempton et al. (1995) suggest three general sets of environmental beliefs play a role in how individuals make sense of environmental issues, 1) nature is a limited resource, 2) nature is balanced and complex and subject to human interference, and 3) disconnection and materialism have caused individuals to devalue nature. These three facets found important by Kempton et al. (1995) are strikingly similar to those constituting the foundational framework of the NEP, 1) balance of nature, 2) limits to growth, and 3) human domination over nature. This fact is strong confirmation of the content validity of the NEP scale. Some studies have shown high construct validity with the NEP scale in providing empirical evidence of the link between age, education, and political ideology with the NEP scale. Environmental knowledge has been shown to be positively correlated with endorsement of the NEP (Arcury 1990, Arcury et al. 1986) and negatively correlated with right-wing, conservative political ideologies (Lefcourt 1996; Schultz and Stone 1994). Dunlap and Van Liere (1978) showed how age was negatively correlated with endorsement of the NEP and education and liberalism were both positively correlated with the NEP.

The dimensionality of the original NEP scale has also been investigated in several studies to debate the notion of whether or not the NEP measures a single construct or multiple constructs. Through factor analysis, three studies (Albrecht et al. 1982, Geller and Lasley 1985, and Noe and Snow 1990) found three distinct dimensions of the NEP scale (discussed above; balance of nature, limits to growth, human domination over nature), but other studies revealed varying results (Edgell and Nowell 1989, Lefcourt 1996). Dunlap et al. (2000) argue that the apparent multidimensionality of the NEP scale stems from the flaw of the original 12-item scale (previously discussed). In their analysis on the ability of the revised 15-item scale being treated as a single construct, Dunlap et al. (2000) calculated a coefficient alpha of 0.83, which suggests an internally consistent measuring instrument (Mueller 1986) and one that clearly measures a single construct.

The NEP scale has been used sparsely in the agricultural sector to predict the behavior of livestock producers in implementing conservation practices. Rahelizatovo (2002) included the NEP scale in a mailed survey to Louisiana dairy farmers. Her intent was to measure the environmental attitude of dairy farmers and then use this attitude to predict their adoption of BMPs. Respondents of the survey were asked to rank their agreement (on a 5-point Likert scale) with each of the 15 items on the scale. Those who strongly agreed with the statements scored five points, mildly agreed scored four points, unsure scored three points, mildly disagreed scored two points, and strongly disagreed scored one point. Scores were then summed and averaged for each individual; a higher score suggested a higher environmental attitude. She hypothesized increased environmental concern and attitude would lead to higher adoption rates of BMPs. Her results showed an average NEP score of 3.22, suggesting that Louisiana dairy producers hold a neutral attitude regarding the statements included in the NEP scale. As a result of their neutral environmental attitude, they were neither more nor less likely to adopt conservation practices. Furthermore, Rahelizatovo (2002) used the Cronbach's alpha equation to measure the internal consistency of the NEP and found a coefficient alpha of 0.78 suggesting high internal validity of the scale.

CHAPTER III

METHODOLOGY

This chapter is subdivided into three sections. The first section discusses the theoretical framework for this study. The second section discusses the analytical framework for this study. The third section discusses the survey instrument, sampling, and data analysis procedures.

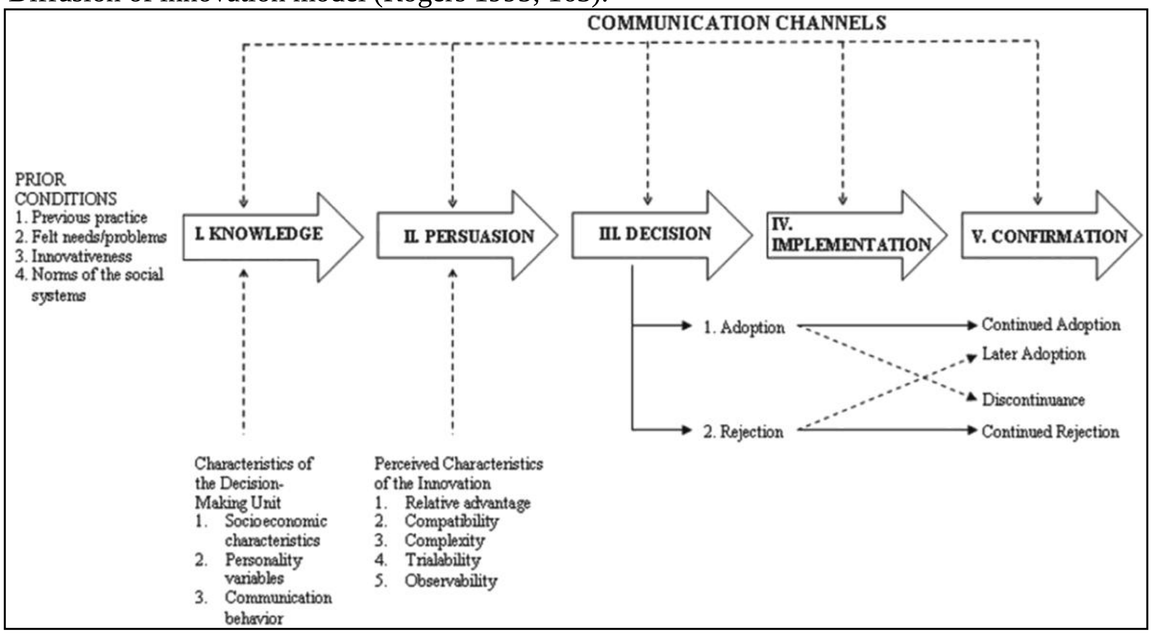
3.1. Theoretical Framework

Understanding the transfer of ideas and technologies within social systems has been studied in many fields. Classic models of behavior adoption include the diffusion of innovation theory (Rogers 2003), the theory of reasoned action (Ajzen and Fishbein 1980), and the theory of planned behavior (Ajzen 1988), which are the most widely used frameworks to explain the adoption of new technologies (Baide 2005). Prokopy et al. (2008) argue research should clearly define a theoretical defense for the inclusion of independent variables so results can be compared across studies. As such, this study will draw on these popular theories to guide the research process.

3.1.1. Diffusion of Innovations

The diffusion of innovations (DOI) theory describes how innovations diffuse through a social system over time. Rogers (2003, 5) defined diffusion as “the process by which an innovation is communicated through certain channels over time among the members of a particular social system; this process includes both planned and spontaneous spread of new ideas.” This definition emphasizes four key elements including innovation, communication, time, and social system (Figure 3.1).

Figure 3.1
Diffusion of innovation model (Rogers 1995, 163).



3.1.1.1 Innovation

Rogers (2003, 12) defined innovation as “any object, idea, technology, or practice that is new.” Thus, innovations can be tangible such as a new piece of farming equipment or intangible such as a change in grazing management. Specific attributes of innovation include relative advantage, compatibility, complexity, trialability, and observability. Relative advantage is “the degree to which an innovation is perceived as being better than the idea it supersedes” (Rogers 2003, 299). In most situations, this is interpreted to mean some sort of financial advantage will be gained by adopting a certain technology as compared to not adopting it. Indeed, research has shown environmental innovations believed to be profitable were more readily adopted over those innovations perceived to carry no economic advantage at all (Barr and Cary 1992, Carboni and Napier 1993, Fuglie and Kascak 2001, McCann et al. 2006). Nowak (1983), however, found some environmentally friendly innovations were adopted even though they were considered to be unprofitable. In addition to economic advantages, other advantages include an increase in social prestige, time-savings, reduction of discomfort, and immediacy of the rewards from the innovation (Rogers 2003).

Rogers (2003, 15) defined compatibility as "the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters." The compatibility of a new innovation within an existing management system has been found to be important in past research (Alonge and Martin 1995; Gamon et al. 1994, Westra and Olson 1997). Inherent within the compatibility characteristic of innovation are the necessity and the applicability of the innovation itself, which have been found to be important factors in previous adoption studies (Battershill and Gilg 1997, Gillespie et al. 2007).

Complexity is defined as "the degree to which an innovation is perceived as relatively difficult to understand and use" (Rogers 2003, 15). Often times, adoption of a new conservation practice may require significant and complex changes to the current operation. Research suggests the more complex a practice, the less likely it is to be adopted (Gamon et al. 1994, Vanclay and Lawrence 1995).

Trialability is defined as “the degree to which an innovation may be experimented with on a limited basis” (Rogers 2003, 16). Conservation practices that can first be installed on a small scale prior to full scale implementation are more likely to be adopted (Gamon et al. 1994, Pannell et al. 2006). When this is possible, producers are able to visually observe the practice (observability) and evaluate the practices’ utility with minimal risk and investment. This suggests the importance of field demonstrations for increasing adoption rates where producers can visually observe a practice in place post-implementation (Hancock 1992). Risk refers to the uncertainty a producer faces concerning the benefits and costs associated with a practice, the uncertainty concerning the practices’ effectiveness, and the uncertainty concerning when the actual benefits from practice implementation will be realized (Cary et al. 2001). Research suggests uncertainty and, therefore, increased risk, concerning an innovation has been found to affect the adoption of that particular innovation (e.g., Pannell 1999; Shortle and Miranowski 1986).

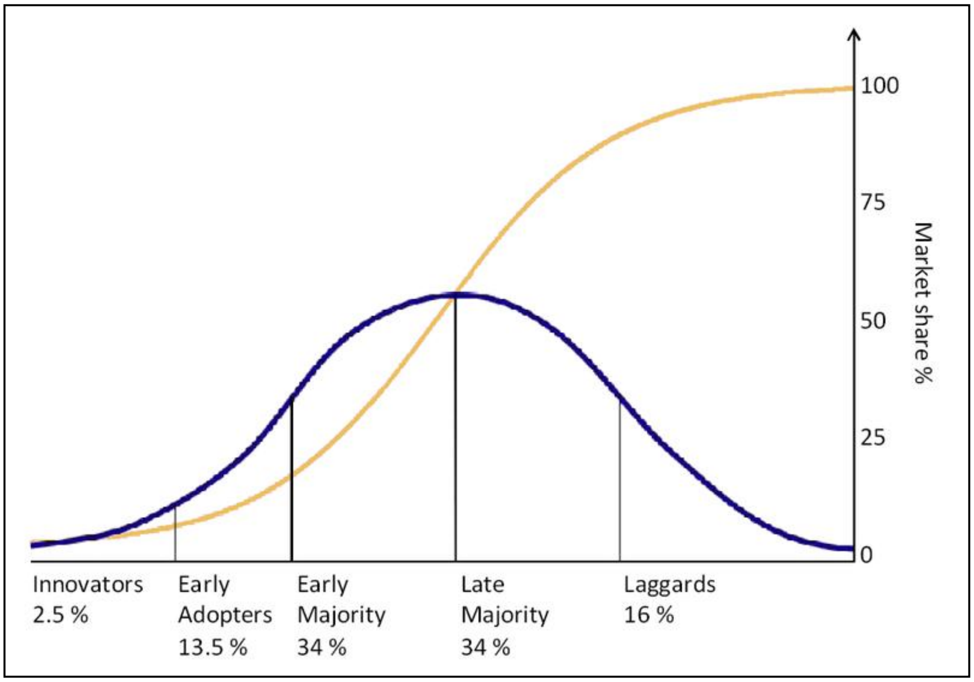
3.1.1.2 Communication Channels

The second key element of the DOI theory is communication channels. Communication refers to the process by which individuals create and share messages with one another in order to reach a mutual understanding regarding a particular topic. A communication channel refers to the means by which these messages are transmitted from one individual to another. Interpersonal communication channels are more effective in creating and changing attitudes towards a new innovation and can greatly influence a producer’s decision to adopt or reject the new innovation. Mass media channels are more effective in creating knowledge and increasing awareness of a new innovation and, therefore, are less able to influence a producers' decision to adopt a certain practice. Research has shown individuals evaluate a new innovation based upon the opinions of their peers who have adopted the innovation rather than upon scientific research conducted on the new innovation (Rogers 2003). In addition, access to information regarding a new technology has a major influence on the adoption decision process (Hooks et al. 1983).

3.1.1.3 Time

The third key element of the DOI theory is related to the amount of time it takes an individual to adopt a new innovation. There are five different categories characterizing individuals based upon the amount of time it takes them to adopt a certain practice (Figure 3.2). The innovators are the first 2.5% to adopt an innovation. Innovators are typically characterized as those with substantial financial resources, the ability to understand and apply complex technical knowledge, and the ability to cope with a high degree of uncertainty. The early adopters are the next 13.5% to adopt an innovation. They are extremely important within a system as they are the group that potential adopters look to for advice and information about the innovation. The early majority is the next 34% to adopt an innovation. This group adopts a new innovation just before the average individual does. They are an important component of the diffusion process as they provide the link between the early and the relatively late adopters. The late majority are the next 34% to adopt an innovation. Unlike the early majority, the late majority adopts a new innovation just after the average individual does. Most often, the late majority are pressured by their peers to adopt an innovation. Finally, the laggards are the last 16% to adopt an innovation. Laggards are characterized as having no opinion leadership, being isolated within their social network, being skeptical of new innovations and change agents, and being comfortable with the status quo.

Figure 3.2
The five categories of adopters within a social system. With successive groups of consumers adopting the new technology (shown in blue), its market share (yellow) will eventually reach the saturation level (Rogers 2003).



The DOI model recognizes adoption as a series of decision phases that occur over a period of time rather than a single decision to adopt or not to adopt (Hornik 2004). Rogers (2003) identified five stages of adoption and diffusion. These stages include knowledge, persuasion, decision, implementation, and confirmation. In the first stage, knowledge, an individual is made aware of a new innovation and has a slight understanding of the nature and function of the innovation. In the second stage, persuasion, an individual interested in the innovation seeks out additional information and forms a positive or negative opinion about the innovation. In the third stage, decision, an individual weighs the advantages and disadvantages of adopting the innovation and makes a decision. In the fourth stage, implementation, an individual actively implements the chosen innovation. In the last stage, confirmation, an individual evaluates the implemented innovation and decides whether or not to continue use of the innovation.

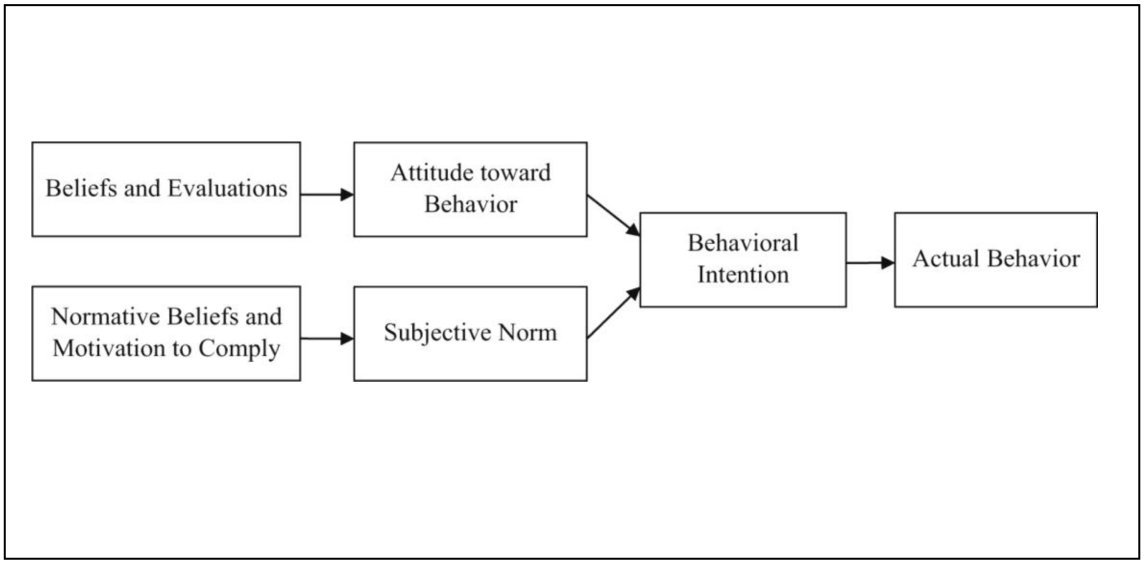
3.1.1.4 Social System

The fourth key element of DOI theory is the social system. The social system is the set of interrelated units that are devoted to joint problem solving to accomplish a common goal (Rogers 2003). Members of a given social system may be individuals, informal groups, organizations, and/or subsystems (Rogers 2003). Innovations are transmitted through the boundaries of a social system. This diffusion is pushed along with the help of a change agent who attempts to influence the adoption decisions of members within a social system.

3.1.2. Theory of Reasoned Action

To explore the influences on a producer's decision to adopt a conservation practice, the theory of reasoned action (TRA), developed by Ajzen and Fishbein (1980), was selected. The TRA is a model that can be used to predict behavioral intention (Figure 3.3). TRA is comprised of three general constructs: behavioral intention, attitude, and subjective norms. Behavioral intention measures an individual's desire to

Figure 3.3
Expanded theory of reasoned action flow model (Azjen and Fishbein 1980).



perform a certain behavior. Attitudes are beliefs that an individual has about performing the behavior. Subjective norms include an individual's perception about the beliefs that others have concerning the behavior in question. When predicting behavior, attitudes and norms are not weighted equally. In essence, the TRA predicts a person's voluntary behavior based on the attitude toward that behavior and how the individual perceives the views of others concerning the behavior. The TRA can be expressed as the following equation (Hale et al. 2003):

$$\mathrm{BI} = (\mathrm{AB})W_1 + (\mathrm{SN})W_2$$

Where:

BI = behavioral intention

AB = one's attitude toward performing the behavior

W = empirically derived weights

SN = one’s subjective norm related to performing the behavior

3.1.3. Theory of Planned Behavior

The TRA was revised and expanded by Ajzen into the theory of planned behavior (TPB; Figure 3.4). This theory links attitudes and behavior and states that an individual’s behavioral intentions are a function of the individual’s attitude toward the behavior, subjective norms, and perceived behavioral control. This revision “was made to account for times when people have the intention of carrying out a behavior, but the actual behavior is thwarted because they lack confidence or control over the behavior" (Miller 2005). Like the TRA, an individual’s intention to perform a certain behavior and the associated subjective norms are key components to the TPB. The TPB adds the additional component of behavioral control, which is defined as one’s perception of the difficulty of performing a behavior (Ajzen 1991). The TPB can be expressed as the following equation (Ajzen 1991):

$$\mathrm{BI} = (\mathrm{W}_1)\mathrm{AB}[(\mathrm{b}) + (\mathrm{e})] + (\mathrm{W}_2)\mathrm{SN}[(\mathrm{n}) + (\mathrm{m})] + (\mathrm{W}_3)\mathrm{PBC}[(\mathrm{c}) + (\mathrm{p})]$$

Where:

BI = behavioral intention

AB = one’s attitude toward performing the behavior

b = the strength of each belief

e = the evaluation of the outcome of the attribute

W = empirically derived weights

SN = one’s subjective norm related to performing the behavior

n = the strength of each normative belief

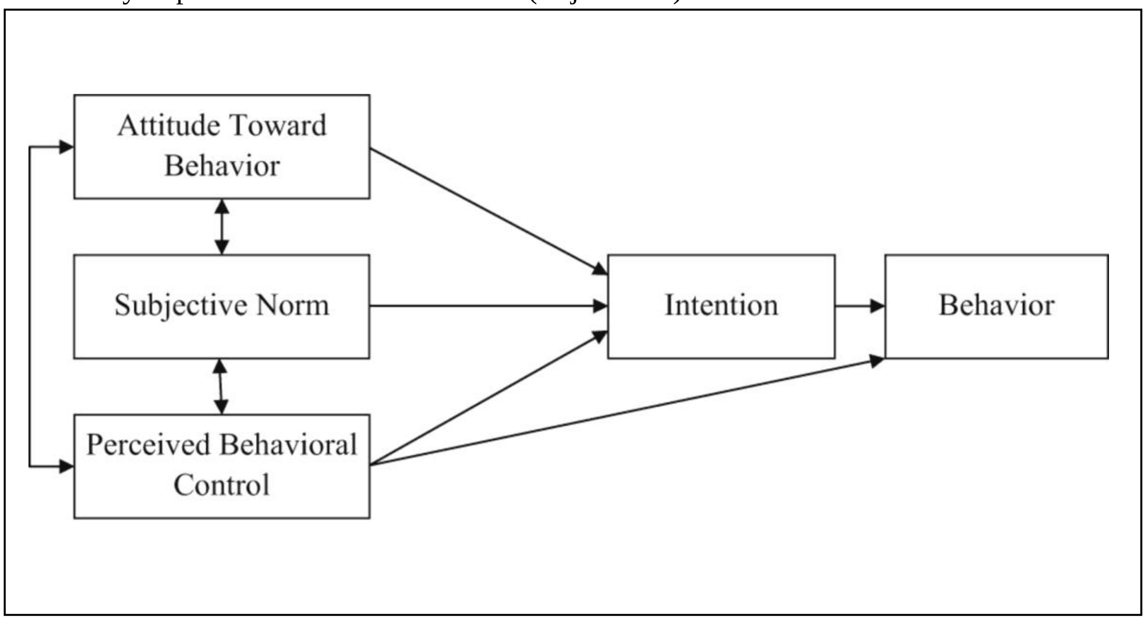
m = the motivation to comply with each belief

PBC = perceived behavioral control

c = the strength of each control belief

p = the perceived power of the control factor

Figure 3.4
The theory of planned behavior flow model (Azjen 1991).



3.2. Analytical Framework

The objective of this study was to determine the barriers Texas beef cattle producers face in implementing conservation practices designed to improve and protect water quality. As such, probit models utilizing both binary and continuous independent variables will be used to estimate the probability of a producer adopting a specific BMP or a set of BMPs given the variables comprising the attitude, capacity, environmental awareness, and farm characteristic constructs (explanatory variables) hypothesized to affect a producers' adoption decision. As Kim et al. (2005, 112) explained, "the probit model is a binary choice model commonly used to analyze the choice behavior of an individual facing two alternatives and opting for one." Bliss (1935) first introduced probit models in his work to find a pesticide that would be effective in controlling insects feeding on grape leaves. Plotting the response of the insects to various concentrations of pesticides produced a sigmoid-shaped curve proving that some pesticides were more effective than others by affecting the insects at different concentrations (Vincent 2008). Bliss did not have a statistically significant way to compare the differences in the relationship between response and dose of pesticide as up until that point, regression had only been used on linear data. To overcome this problem, Bliss developed the idea of transforming the sigmoid-shaped curve into a straight line to fit a regression of the response of the insects to the dose of pesticide. Davis Finney expanded on Bliss' idea and wrote *Probit Analysis* in 1952.

In its simplest terms, regression is a statistical technique that "attempts to predict the values of a given variable, (termed the dependent, outcome, or response variable) based on the values of one or more other variables (called independent variables, predictors, or covariates). The result of a regression is usually an equation (or model) that summarizes the relationship between the dependent and independent variable(s)" (Guido et al. 2006, 1).

The choice a livestock producer has in adopting a conservation practice has only two outcomes and therefore, represents a binary response variable—a producer will either adopt a practice or they will not adopt a practice. A livestock producer will choose to adopt a conservation practice if the utility associated with its adoption is greater than the utility associated with its non-adoption (Kim et al. 2005). Because some factors hypothesized to impact the level of utility obtained can't be observed (i.e., awareness, preferences, etc.), utility is said to be random (Train 2009). The linear random utility assumption can be expressed in the following equation (Rahelizatovo 2002):

$$U_{i0} = \overline{U}_{i0} + e_{i0} = z_{i0}{}'\delta + w_{i0}{}'\gamma + e_{i0}$$

$$U_{i1} = \overline{U}_{i1} + e_{i1} = z_{i1}{}'\delta + w_{i1}{}'\gamma + e_{i1}$$

Where:

$\overline{U}_i$ = the average utility perceived by an individual *i*

e_i= error associated with an individual's (*i*) choice

z_i= vector of attributes associated with alternative choices

w_i= attributes specific to individual *i*

The choice to adopt a practice is an individual producer decision. In this study, the probability of a producer adopting one of the 18 conservation practices in question (P_i) is hypothesized to be a function of attitude (*a*), capacity (*c*), environmental awareness (*e*), and farm characteristic (*f*) constructs, which is presented in the following equation (Van Winkle and Hadrich 2011):

$P_i = f(a, c, e, f)$

The equation can be expanded to include individual independent variables comprising these constructs that are hypothesized to influence adoption rates of a single conservation practices (Van Winkle and Hadrich 2011) and can be analyzed using a univariate probit model:

$$P_i = X\beta + \varepsilon_t$$

Where:

P_i = binary variable equal to 1 for BMP adoption and 0 for non-adoption

X = vector of independent variables hypothesized to affect the probability of BMP adoption

β = vector of estimated parameters

ε_t = error term (assumed to be normally distributed to allow for maximum likelihood estimation in the probit model)

i = BMP type

As previously discussed, independent variables hypothesized to influence a producer's decision to adopt a conservation practice are divided into four categories related to attitude, capacity, environmental awareness, and farm characteristics. Attitude includes characteristics related to adoption payments, profitability of practice, heritage, and risk. Capacity includes characteristics related to age, diversity of operation, education, farming experience, income, information, labor, and networking. Environmental awareness includes characteristics related to environmental attitude, causes of pollution, quality of environment, consequences of degraded ecosystems, knowledge of nonpoint source programs, and general terms related to environmental quality. Finally, farm characteristic includes total acres, applicability/compatibility or practice, capital, land tenure, operator gender, ownership type, and proximity of water body to operation.

A number of studies have successfully used probit analysis to examine the influence of economic and non-economic factors on the adoption of conservation practices or other innovative technologies. In terms of cropping technologies, Gabrielyan (2010) used a probit model to evaluate factors affecting the adoption of cover crops by farmers in the Mississippi River Basin. Rahm and Huffman (1984) used probit analysis to understand the role of human capital and other variables in the adoption of reduced tillage practices by Iowa farmers. Frisvold et al. (2009) examined the adoption of 10 BMPs related to weed control and resistance by cotton, corn, and soybean growers in the Great Plains region of the United States. Probit regressions were used to examine the effects of socioeconomic and other variables on the total number of weed resistance BMPs adopted by farmers. Fernandez-Cornejo et al. (2002) used probit analysis to examine the economic and non-economic factors that influence the adoption of herbicide-tolerant soybeans by farmers in the United States. Finally, Henning and Cardona (2000) used multivariate probit analysis to examine the factors that influence adoption of BMPs by Louisiana sugarcane producers.

Regarding producer adoption of livestock-specific BMPs, Rahelizatovo (2002) used probit analysis to understand the characteristics associated with the adoption of conservation practices by Louisiana dairy farmers. Obubuafo et al. (2008) utilized probit analysis to understand the awareness of EQIP by Louisiana livestock producers and how this awareness affected implementation of the EQIP program. Kim et al. (2005) used probit models to estimate the socioeconomic factors that influenced adoption of BMPs by Louisiana beef cattle producers. Gedikoglu and McCann (2012) conducted probit analysis to examine the adoption of manure testing, growing Roundup Ready soybeans, manure spreader calibration, and stream buffers by livestock producers in Iowa and Missouri. Cooper and Keim (1996) used bivariate probit models to predict farmer adoption of integrated pest management, legume crediting, manure testing, split applications of nitrogen, and manure testing. Van Winkle and Hadric (2011) used probit models to examine the likelihood of production practice adoption among North Dakota beef cattle producers. Finally, Gedikoglu and McCann (2007) utilized multivariate probit regression to predict the impact of off-farm income on the adoption of capital-intensive practices such as manure injection practices.

3.3. Methodology

This study attempted to answer five research questions:

1. What are the current levels of adoption of water quality best management practices among Texas beef cattle producers?
2. What are the current levels of maintenance of water quality best management practices among Texas beef cattle producers?
3. What are the major barriers related to the non-adoption of water quality best management practices by Texas livestock producers?
4. What are the major barriers related to non-participation in government funded cost-share programs by Texas beef cattle producers?

5. How do capacity, attitudes, environmental awareness, and farm characteristics influence the adoption behavior of Texas beef cattle producers in implementing water quality best management practices?

3.3.1. Research Approach

A mixed-mode research approach employing mail and electronic survey instrument formats was utilized to conduct a statewide survey of Texas beef cattle producers between August and November 2013. The survey investigated how variables related to capacity, environmental awareness, attitude, and farm characteristics influenced a producer's decision to adopt one or more BMPs known to reduce bacterial contamination of surface water bodies. A mixed-mode approach is effective for increasing response rate (Dillman et al. 2009), reducing mailing costs (Dillman 2000, Schaefer and Dillman 1998), providing more timely data (Archer 2003), and reducing coverage and non-response error (Dillman and Tarnai 1988).

Prior to commencement of research activities, approval was received from the Texas A&M University Institutional Review Board (IRB) through the Office of Research Compliance's Human Subjects Protection Program under protocol number TAMU IRB#2012-0236 (Appendix A).

3.3.2. Population and Sample

The population for this study was Texas beef cattle producers. The 2007 Census of Agriculture estimates there are 131,769 beef cattle producers in the state. The sampling frame for this study was derived from a list of all beef cattle producers in Texas maintained by the Southern Plains Regional Field Office of NASS.

A stratified random sample with substitution was utilized as the sampling scheme for this study. The sample was drawn by the Southern Plains Regional Field Office of NASS in August 2013; the student researcher did not have access to any identifiable information such as name and mailing address. The population of beef cattle operations maintained by NASS (N = 131,769) was sorted by county and size. Size was determined by the number of cattle reported by the operation on the 2012 USDA Census of Agriculture or most recent NASS survey.

Within each county, the population was subdivided into three size groups: small, medium, and large. Size group boundaries were identified in each county so that records in the small group had between 1 and the 25th percentile cattle, the medium group between the 25th and 75th percentile, and the large group above the 75th percentile. The initial sample scheme was to select 1 or 2 records from the small and large size groups, and 2 or 3 records from the medium size group in each county.

The population was sorted by county, group size, and a random unique value. A random starting point was calculated for each size group to be between 1 and a computed sampling interval specific to that size group and county. The interval was calculated as the number of records in the population for the size group in the county divided by the number of samples desired (2 for small/large or 3 for medium). The sample was then selected, starting with the interval record, followed by the interval * 2 record, etc. until the population was exhausted for the specific county/size group.

Substitution was applied for specific special circumstances. There were some records in the population where NASS had special agreements with operators to minimize the number of contacts, for example. If a special handle record was sampled, the next record in the order of the sorted population was substituted as needed.

After the initial sample was identified (1,778 records were originally sampled), the list was scrutinized to remove out-of-state or potentially undeliverable addresses, and any inadvertent duplication to reduce the final sample to 1,700. Utilizing a 5% margin of error and estimating a response rate of 30%, a minimum of 384 responses were needed to produce a statistically valid sample.

Sample size was calculated using Cochran's (1977) sample size formula:

$$\underline{n}_0 = \frac{(t)^2 \ * \ (p)(q)}{(\underline{d})^2}$$

$$\underline{n}_0 = \frac{(1.96)^2 \ * \ (0.5)(0.5)}{(\underline{0.05d})^2} = 384$$

Where:

t = value for selected alpha level of .025 in each tail = 1.96 (the alpha level of .05 indicates the level of risk the researcher is willing to take that true margin of error may exceed the acceptable margin of error).

(p)(q) = estimate of variance = 0.25. (maximum possible proportion (0.5) * 1- maximum possible proportion (0.5) produces maximum possible sample size).

d = acceptable margin of error for proportion being estimated =0.05 (error researcher is willing to except).

3.3.3. Instrumentation

An initial draft survey instrument was developed as part of a course requirement for the spring 2012 section of ALEC 620: Instrumentation and Survey Research Methods utilizing the questionnaire created by Rahelizatovo and Gillespie (2004) as a preliminary guide. An electronic version of the paper questionnaire was created using Qualtrics™ (www.qualtrics.com). Both versions of the survey instrument were pilot tested with a total of 68 beef cattle producers in April and August 2012. Approximately 2/3 completed the paper version (n = 43) and 1/3 (n = 25) completed the electronic version. Final versions of the survey instruments were completed in May 2013. The paper version of the instrument was designed as a scan form to eliminate the need for manual data entry; to select answers, participants either filled in a circle next to the answer choice or wrote their answer (Appendix B). The electronic survey instrument automatically recorded participant answers through the Qualtrics™ platform; to select answers, participants clicked on a circle next to their indicated answer choice.

There were a total of 36 questions in the paper survey and 44 questions in the online survey. Advanced programming capabilities in Qualtrics™ (i.e., JavaScript, Skip Logic, Display Logic) allowed the student researcher to separate some questions in the online version (i.e., “If Yes” questions) that were combined in the paper version. For example, an online participant selecting “No” to the adoption of shade structures was not burdened with having to read the next part of the question about whether they maintained the shade structure after adoption. Other than the different number of questions, the electronic and paper versions of the survey were nearly identical and contained the same questions.

The survey questions were divided into four categories to determine production characteristics, environmental attitude, BMP adoption and barriers to adoption, and producer characteristics. Survey questions comprised a combination of Likert-scale, dichotomous (Yes/No), and multiple choice items designed to directly address the awareness, capacity, environmental attitude, and farm characteristics constructs, which were based on the meta-analysis conducted by Prokopy et al. (2008) and founded on the theoretical framework discussed in Chapter II.

3.3.4. Reliability and Validity

Cronbach's (1951) alpha was used to determine reliability of scaled items during both pilot tests ($\alpha \geq 0.7$). Based on this reliability measure, less-reliable questions were removed or reworded and additional questions were added to more accurately address the research objectives of the study. Content and face validity of the instrument were determined through pilot testing and use of a panel of experts comprised of livestock producers, the student researcher's graduate committee, and other Soil and Crop Sciences faculty members.

3.3.5. Data Collection and Mailing Protocol

This study followed Dillman's *Tailored Design Method* (Dillman et al. 2009) which has been successful in securing high response rates from evaluated participants. A 4-stage survey mailing was utilized and included a welcome postcard, survey packet one, a reminder postcard, and survey packet two. All postcards and survey packet cover letters were hand-signed by the student researcher. All correspondence materials also were marked by a sequence number that ranged from 0001 to 1700. These codes were randomly assigned to participant mailing addresses provided by NASS. Utilizing sequence numbers allowed mailing addresses to remain confidential to the student researcher (per NASS confidentiality requirements) and allowed tracking of completed surveys to prevent duplicate mailings to participants.

On August 14, 2013, individuals were mailed a 4” x 6” color postcard notifying them they had been selected to complete a survey and to expect receipt of the survey within approximately one week (Appendix C). The postcard included a web link providing participants the option to complete an electronic version of the survey online rather than the paper version. One-half of the postcards (ID# 0001-0850) contained a shortened URL (http://tx.ag/BMPsurvey) and the other one-half (ID# 0851-1700) contained a longer URL link (http://tx.ag/tamuag-extension-BMPsurvey) so that comparisons could be made concerning the effect of URL length on response rates to electronic surveys.

On August 19, 2013, approximately one week after the postcards were distributed, individuals who chose not to complete the survey online received an initial survey packet containing a cover letter with instructions on completing the survey (Appendix D), a paper questionnaire, a $1 bill, and a business reply envelope to return the completed questionnaire. A $1 incentive payment was included to maximize response rates. Small prepaid incentives have been shown to increase response rates by 8% to 31% compared to no incentive (Dillman et al. 2009). In the agricultural sector, Fausti and Gillespie (2000) used an incentive payment to increase the response rate on a survey studying the risk attitudes of beef producers in Louisiana.

On August 26, 2013, individuals received a follow-up 4” x 6” color postcard thanking those who had already completed the survey and requesting a response from those who had not yet responded (Appendix E). Lastly, on September 10, 2013, approximately two weeks following the mailing of the reminder postcard, individuals who still had not responded (either on paper or electronically) were sent a new cover letter (Appendix F), paper questionnaire, and pre-paid return envelope. No incentive payment was supplied in the second survey packet.

Data collection ceased on November 1, 2013. Nineteen postcards and/or survey packets were returned undeliverable, 14 individuals reported they had sold all of their cattle, and 43 individuals indicated they did not wish to participate in the study. This yielded a frame error of 4.5% and reduced the total sample to 1,624 beef cattle producers. A total of 93 surveys (5.7%) were completed online and 686 (42.3%) were completed on paper and mailed back to the student researcher for a total response rate of 48.0% (Table 3.1).

Table 3.1
Response rate by size group.

Size Group	**Original Sample**	**UAA**	**Out of Business**	**Refusal**	**Sample 1/**	**Completed**	**Response Rate**
Small	460	8	5	9	438	228	52.1
Medium	784	7	6	26	745	342	45.9
Large	456	4	3	8	441	209	47.4
Total	1700	19	14	43	1,624	779	48.0

UAA = undeliverable, post office returns.
Sample 1/ excludes UAAs, Out of Business, and Refusals.
Response Rate = Completed ÷ Sample 1/

3.3.6. Data Preparation

Completed paper surveys were scanned using Cardiff Teleform automated computer recognition software and then exported to the Statistical Package for the Social Sciences (SPSS) Version 20 for preparation and analysis. Electronic survey responses were downloaded from Qualtrics™ and merged into SPSS with the results from the paper surveys. Prior to exporting and merging survey results, the files were scanned for irregularities and corrections were made to the raw datasets in SPSS. As a final check on the quality and consistency of the datasets, frequency counts were run on all data and any outliers were identified and checked against the actual survey response.

There were two cases in which an individual had completed duplicate survey instruments on paper and online. The individuals responses were compared, but inconsistencies between the responses resulted in these responses being eliminated from the final analysis.

Dummy variables were created for several independent variables for use in the univariate probit analyses (Table 3.2). All scaled items were recoded in the dataset so that strongly disagree = 1, disagree = 2, neither agree nor disagree = 3, agree = 4, and strongly agree = 5. In addition, odd-numbered questions comprising the NEP scale (Q9B, Q9D, Q9F, Q9H, Q9J, Q9L, and Q9N) were reverse coded so that answers on all 15 items reflected the same direction of response from strongly disagree to strongly agree. In addition, 5 items comprising the water quality attitude scale (Q3E, Q3F, Q3I, Q3J, Q3L) were reverse coded so that answers on all 12 items reflected the same direction of response from strongly disagree to strongly agree. Finally, two new latent variables were created to reflect the individual mean responses to the summated scaled items for both the water quality attitude (WATT) and environmental attitude/NEP scale (EATT).

Table 3.2
Recoded dummy variables for use in the univariate probit analyses.

Dummy Variable	**Description**	**Coding**
Q1_RC	Livestock diversity	0=one type of livestock; 1=more than one type of livestock
Q2_RC	Crop diversity	0=one type of crop; 1=more than one type of crop
Q17_RCD	Bachelor’s degree	0=no degree; 1=bachelor’s degree or higher
Q23_RCD	Labor on farm	0=no family members; 1=one or more family members
Q24_RCD	Family members	0=no or unsure; 1=yes family members will take over farm
Q25_RCD	2012 Extension visits	0=no visits; 1=one or more visits
Q26_RCD	2012 NRCS visits	0=no visits; 1=one or more visits
Q33_RCD	Risk aversion	0=risk neutral; 1=risk aversion
Q35_RCD	Nearest water body	0=no stream near property; 1=stream through property
Q36_RCD	Water quality rating	0=fair or less; 1=good or better

3.3.7. Non-Response Bias

Non-response bias in survey research is undesirable, but often unavoidable. One conservative approach to handling non-response bias is to limit the inferences of the study. A more liberal approach is to avoid it all together. As a mediating approach, non-response bias was evaluated by comparing early and late survey respondents (August/September vs. October respondents) on key demographic variables (Newman 1962). Independent samples *t* and chi-square tests showed no significant differences on age (t = 2.73; p = .070), gender (χ^2 = 0.453; p = 0.501), education level (χ^2 = 3.614; p = 0.461), annual income (χ^2 = 4.392; p = 0.355), and total acreage (t = 1.37; p = 0.171) between early and late respondents.

3.3.8. Statistical Analyses Procedures

Statistical analyses were conducted using Version 20 of SPSS with the generalized linear mixed model (GLMM) module add-on and Version 10 of LIMDEP. All analyses syntax is included in Appendix G. The alpha level for data analyses was set *a priori* at 0.05. Descriptive statistics were utilized to answer research questions 1 through 4. Only individuals with beef cattle were included in the analysis. Frequencies and percentages were calculated for water quality BMPs participants indicated as having adopted on their property as responses to these questions were either Yes or No. Frequencies, percentages, means, and standard deviations were calculated for questions related to demographic characteristics of producers (i.e., age, acreage, income, animals raised, etc.); for water quality BMPs participants agreed with having maintained on their property; for barriers indicated by participants as having impacted their decision to adopt water quality BMPs; and for barriers indicated by participants as having impacted their decision to participate in a government-funded cost-share program. For the water quality attitude (Q3A-Q3L) and environmental attitude (NEP scale; Q9A-Q9O) scales, reliability analysis was first conducted to determine the internal consistency of each measurement scale. Both scales had good internal consistency with $\alpha = 0.737$ for the water quality attitude scale and $\alpha = 0.829$ for the environmental attitude (NEP) scale.

Inferential statistics were utilized to answer research questions 5. To determine how capacity, attitudes, environmental awareness, and farm characteristics impacted producer decisions to adopt water quality BMPs, univariate probit regression models were utilized. Prior to analysis, multicollinearity diagnostics were run on all 30 independent variables hypothesized to influence producer adoption of water quality BMPs. Tolerance and variance inflation factor (VIF) collinearity statistics as well as collinearity diagnostics comprised of eigenvalues (λ_i), condition indices (η_i), and the proportion of variation matrix were examined. Next, 18 univariate probit analyses were conducted including only the variables retained from the multicollinearity tests. Goodness of fit for each model was estimated using McFadden's R^2 statistic and the percent correctly predicted measure. Marginal effects at mean values of all independent variables were also calculated as they represent the partial effects of each explanatory variable on the probability that the observed dependent variable is equal to 1 (i.e., BMP was adopted). Estimates of marginal effects constitute the commonly reported summary measure in many studies utilizing probit analyses. It was initially thought multivariate probit analyses would be used to examine the influence of predictor variables on the adoption of a set of correlated practices. However, correlations between the 18 practices revealed low Pearson's correlation coefficients for all practices indicating weak linear relationships among the practices. Consequently, multivariate analysis was not warranted.

Descriptive statistics and empirical results from the univariate probit analysis are presented in the next chapter. Discussion of the results is also provided.

CHAPTER IV

RESULTS AND DISCUSSION

This chapter will first present a general description of producer respondents to the survey by detailing descriptive statistics for key demographic, knowledge, and attitudinal variables. The second part of the chapter will discuss specific results for each of the 5 research questions presented in Chapter III.

4.1. Descriptive Statistics

4.1.1. General Demographic Characteristics of Respondents

General demographic characteristics of respondents are presented in Table 4.1. Survey respondents were primarily male (86.6%) with some level of college or technical school education (32%). Nearly 18% of respondents held advanced degrees. The mean age of respondents was approximately 63 years (*SD* =11.7). More than half of survey respondents (52.1%) received more than 80% of their income from an off-farm source whereas 2.1% of respondents received the same proportion of income from their beef cattle operation. Ranching experience among respondents averaged 26 years.

Production characteristics of respondents are presented in Table 4.2. Operations averaged approximately 1,865 acres (*SD* = 6539.6) with respondents reporting they owned and operated approximately 85% of the total acreage. Ninety-six percent of respondents owned beef cattle, 25.2% owned horses, 47.7% grew hay, and 11.8% grew wheat. General characteristics or producers’ awareness of water quality issues and best management practices are presented in Table 4.3.

Table 4.1
Descriptive statistics of key demographic variables for respondents completing the paper and web versions of the survey instrument.

	Web				***Paper***				***Total***			
Variable	***f***	***%***	***M***	***SD***	***f***	***%***	***M***	***SD***	***f***	***%***	***M***	***SD***
Sex	—	—	—	—	—	—	—	—	—	—	—	—
Male	584	86.6	—	—	77	86.5	—	—	661	86.6	—	—
Female	90	13.4	—	—	12	13.5	—	—	102	13.4	—	—
Education	—	—	—	—	—	—	—	—	—	—	—	—
Less than high school	19	2.8	—	—	3	3.4	—	—	22	2.9	—	—
High school or GED	159	23.4	—	—	12	13.5	—	—	171	22.2	—	—
Some college/technical school	225	33.1	—	—	25	28.1	—	—	250	32.5	—	—
College Bachelor's degree	159	23.4	—	—	30	33.7	—	—	189	24.6	—	—
Advanced degree	118	17.4	—	—	19	21.3	—	—	137	17.8	—	—
% income from operation	—	—	—	—	—	—	—	—	—	—	—	—
0	99	22.8	—	—	14	16.5	—	—	113	14.4	—	—
1-20	262	60.2	—	—	53	62.4	—	—	315	40.1	—	—
21-40	40	9.2	—	—	10	11.8	—	—	50	6.4	—	—
41-60	19	4.4	—	—	6	7.1	—	—	25	3.2	—	—
61-80	5	1.1	—	—	1	1.2	—	—	6	0.8	—	—
81-100	10	2.3	—	—	1	1.2	—	—	11	2.1	—	—
% income from off farm source	—	—	—	—	—	—	—	—	—	—	—	—
0	36	8.6	—	—	5	5.8	—	—	41	8.1	—	—
1-20	39	9.3	—	—	6	7.0	—	—	45	8.9	—	—
21-40	23	5.5	—	—	3	3.5	—	—	26	5.1	—	—
41-60	31	7.4	—	—	9	10.5	—	—	40	7.9	—	—
61-80	77	18.3	—	—	14	16.3	—	—	91	17.9	—	—
81-100	215	51.1	—	—	49	57.0	—	—	264	52.1	—	—
Age	—	—	63.5	11.5	—	—	58.3	12.0	—	—	62.9	11.7
Experience	—	—	25.7	17.3	—	—	27.0	41.0	—	—	25.9	21.4

Table 4.2
Production characteristics of beef cattle producers completing the paper and web versions of the survey instrument.

	Web				Paper				Total			
Variable	***f***	***%***	***M***	***SD***	***f***	***%***	***M***	***SD***	***f***	***%***	***M***	***SD***
Total acreage in operation	—	—	1919.4	6709.1	—	—	1436.1	5017.5	—	—	1864.9	6539.6
Acres owned	—	—	1552.3	7426.2	—	—	1857.3	7249.8	—	—	1587.4	7402.1
Acres rented	—	—	1011.5	5422.2	—	—	301.6	503.5	—	—	928.16	5101.3
Livestock raised	—	—	—	—	—	—	—	—	—	—	—	—
Beef	654	95.1	—	—	91	98.9	—	—	745	95.3	—	—
Dairy	2	0.3	—	—	1	1.1	—	—	3	0.4	—	—
Poultry	52	7.6	—	—	9	9.8	—	—	61	8.3	—	—
Swine	10	1.5	—	—	0	0.0	—	—	10	1.4	—	—
Horses	160	23.3	—	—	36	39.1	—	—	196	26.3	—	—
Goats	62	9.0	—	—	15	16.3	—	—	77	10.5	—	—
Sheep	18	2.6	—	—	6	6.5	—	—	24	3.3	—	—
Other	26	3.8	—	—	5	5.4	—	—	31	4.3	—	—
Crops grown	—	—	—	—	—	—	—	—	—	—	—	—
Corn	14	2.0	—	—	1	1.1	—	—	15	2.2	—	—
Fruits	9	1.3	—	—	2	2.2	—	—	11	1.6	—	—
Oats	42	6.1	—	—	8	8.7	—	—	50	7.3	—	—
Sorghum	25	3.6	—	—	6	6.5	—	—	31	4.5	—	—
Timber	21	3.1	—	—	4	4.3	—	—	25	3.6	—	—
Wheat	82	11.9	—	—	10	10.9	—	—	92	13.2	—	—
Cotton	19	2.8	—	—	2	2.2	—	—	21	3.0	—	—
Hay	323	47.0	—	—	48	52.2	—	—	371	50.5	—	—
Rice	3	0.4	—	—	0	0.0	—	—	3	0.4	—	—
Soybeans	2	0.3	—	—	0	0.0	—	—	2	0.3	—	—
Vegetables	10	1.5	—	—	2	2.2	—	—	12	1.7	—	—
Other	25	3.6	—	—	6	6.5	—	—	31	4.5	—	—

Table 4.3
Awareness of water quality issues and best management practices among beef cattle producers completing the paper and web versions of the survey instrument.

	Paper		***Web***		***Total***	
Variable	***f***	***%***	***f***	***%***	***f***	***%***
Awareness of:	—	—	—	—	—	—
Best management practice	—	—	—	—	—	—
Yes	336	49.7	49	53.3	385	50.1
No	340	50.3	43	46.7	383	49.9
Nonpoint source pollution	-	-	-	-	-	-
Yes	151	22.3	26	28.9	177	23.1
No	526	77.7	64	71.1	590	76.9
Statewide bacteria impairments	—	—	—	—	—	—
Yes	253	37.6	32	35.2	285	37.4
No	419	62.4	59	64.8	478	62.6
Clean Water Act	—	—	—	—	—	—
Yes	200	29.9	34	37.8	234	30.9
No	468	70.1	56	62.2	524	69.1
Financial assistance programs	—	—	—	—	—	—
Yes	105	15.6	13	14.1	118	15.5
No	566	84.4	79	85.9	645	84.5

Approximately half (50.1%) of the respondents were aware of the term "best management practice" whereas 23.1% were aware of the term "nonpoint source pollution." Furthermore, 62.6% of respondents were not aware elevated levels of bacteria were the major cause of impairment in Texas surface water bodies. Nearly 70% of respondents were not aware of efforts to control nonpoint source pollution through the Clean Water Act while only 15.5% were aware of the availability of financial assistance programs to assist in conservation practice implementation. The lack of awareness of financial incentive programs may be justified given not all programs are available in every county of the state.

General characteristics of producers related to conservation program information sources, preference of format for conservation program information, and networking variables are presented in Table 4.4. Nearly 43% of respondents indicated other farmers as their primary source for water quality information as compared to only 1.2% for environmental advocacy groups. Nearly 66% of respondents indicated publications (factsheets, brochures, manuals, etc.) as their preferred format for water quality

Table 4.4
Conservation program information sources, preference of format for conservation program information, and Extension/Natural Resources Conservation Services (NRCS) networking of beef cattle producers completing the paper and web versions of the survey instrument.

	Paper		***Web***		***Total***	
Variable	***f***	***%***	***f***	***%***	***f***	***%***
Primary source of conservation program info.	—	—	—	—	—	—
Environmental advocacy group	9	1.3	0	0.0	9	1.2
Farm/ranch business	101	14.7	6	6.9	107	13.8
Farm/ranch organization	77	11.2	10	11.5	87	11.2
Non-Extension media	48	7.0	5	5.7	53	6.8
Natural Resources Conservation Service	154	22.4	14	16.1	168	21.7
Other farmers/ranchers	301	43.8	30	34.5	331	42.8
Soil and Water Conservation District	88	12.8	10	11.5	98	12.7
Texas A&M AgriLife Extension	104	15.1	12	13.8	116	15.0
Preferred format of conservation program info.	—	—	—	—	—	—
Email	88	12.8	29	33.0	117	15.1
Internet	43	6.3	11	12.5	54	7.0
Newspaper	85	12.4	5	5.7	90	11.6
Publications	470	68.4	38	43.2	508	65.5
Radio	26	3.8	2	2.3	28	3.6
Social media	7	1.0	0	0.0	7	0.9
Television	62	9.0	3	3.4	65	8.4
Member of livestock organization	—	—	—	—	—	—
Yes	151	22.2	30	34.1	181	23.6
No	529	77.8	58	65.9	587	76.4
Visits with Extension in 2012	—	—	—	—	—	—
None	413	60.8	48	53.9	561	60.0
1-3 times	209	30.8	35	39.3	244	31.8
4 times or more	57	8.4	6	6.7	63	8.2
Visits with NRCS in 2012	—	—	—	—	—	—
None	452	66.8	59	66.3	511	66.7
1-3 times	168	24.8	21	23.6	189	24.7
4 times or more	57	8.4	9	10.1	66	8.6

information. Less than 1% of respondents preferred to receive water quality information via social media outlets including, Facebook and Twitter. More than 75% of respondents indicated they were not members of a Texas livestock organization such as the Texas and Southwestern Cattle Raisers Association or Texas Cattle Feeders Association. Finally, 60.0% and 66.7% of producers indicated they have zero contact with Texas A&M AgriLife Extension Service and the NRCS in a typical year, respectively.

A summary of the distribution of the producers' responses to the NEP statements is presented in Table 4.5. The grand mean of producer responses to all NEP items was 3.2 (*SD* = 0.54) indicating a very neutral environmental attitude. As previously discussed, agreement with the eight odd-numbered items and disagreement with the seven even-numbered items indicates a pro-environmental view. The frequency distribution of the responses shows that more than 50 percent of respondents hold a pro-environmental view regarding statements 3, 5, 7, 8, 9, 13 and 14. Particularly, more than 60% of the producers agree with the views in statements 3, 9, and 13 which stipulate the disastrous consequences of human interference with nature, humans being subject to the laws of nature, and the delicate and easily upset balance of nature. Nearly 90% of respondents agreed with item 9 alone (humans being subject to the laws of nature). More than 50 percent of respondents disagreed with items 8 and 14 related to the strength of the balance of nature to cope with the impacts of modern industrial nations and the eventual ability of humans to control nature. More than 41% of respondents disagreed with item 2 related to humans having the right to modify the natural environment to suit their needs.

Table 4.5
Descriptive statistics for environmental attitude (NEP) statements.

NEP Statement	SD	D	NAND	A	SA	Total	
			%			*M*	*SD*
1. We are approaching the limit of the number of people the earth can support.	4.9	25.3	29.4	31.3	9.0	3.1	1.1
2. Humans have the right to modify the natural environment to suit their needs.	7.1	34.3	27.9	26.1	4.5	2.9	1.0
3. When humans interfere with nature it often produces disastrous consequences.	1.4	10.1	20.9	55.7	12.0	3.7	0.9
4. Human ingenuity will insure that we do NOT make the earth unlivable.	5.1	21.4	35.0	34.1	4.4	3.1	1.0
5. Humans are severely abusing the environment.	4.5	16.8	25.0	41.2	12.4	3.4	1.0
6. The earth has plenty of natural resources if we just learn how to develop them.	1.4	10.4	16.9	60.7	10.6	3.7	0.8
7. Plants and animals have as much right as humans to exist.	7.7	19.3	17.5	43.4	12.2	3.3	1.1
8. The balance of nature is strong enough to cope with the impacts of modern industrial nations.	8.9	47.1	25.4	16.3	2.3	2.6	0.9
9. Despite our special abilities, humans are still subject to the laws of nature.	0.1	1.8	9.0	72.5	16.5	4.0	0.6
10. The so-called 'ecological crisis' facing humankind has been greatly exaggerated.	5.6	21.0	32.0	31.9	9.4	3.2	1.0
11. The earth is like a spaceship with very limited room and resources.	5.4	28.7	29.0	31.7	5.2	3.0	1.0
12. Humans were meant to rule over the rest of nature.	7.0	22.4	25.1	34.2	11.3	3.2	1.1
13. The balance of nature is very delicate and easily upset.	1.4	17.1	18.6	53.2	9.8	3.5	0.9
14. Humans will eventually learn enough about how nature works to be able to control it.	9.6	41.3	32.8	14.5	1.8	2.6	0.9
15. If things continue on their present course, we will soon experience a major ecological catastrophe.	7.1	23.7	33.1	28.5	7.7	3.1	1.1
Total	—	—	—	—	—	**3.19**	**0.54**

Notes. SD = strongly disagree; D = disagree; NAND = neither agree nor disagree; A = agree; SA = strongly agree; *M* = mean; *SD* = standard deviation.

Items 6, 10, and 12 showed a greater percentage of respondents against the environmental view. Approximately 71 percent agreed with item 6, which stated “the earth has plenty of natural resources if we just learn how to develop them”, 41 percent considered the so-called “ecological crisis” facing humankind as being greatly exaggerated, and 45% believed humans were meant to rule over the rest of nature.

Items 4, 10, 14, and 15 received the highest proportions of “neither disagree nor agree” responses. Thirty five percent of respondents were unsure whether human ingenuity would make the earth unlivable, 32% were uncertain about the ecological crisis statement, 33% were unsure about humans being able to control nature, and 32% were indecisive about an eventual major ecological catastrophe in the near future.

A summary of the distribution of the producers’ responses to the water quality attitude (WATT) statements is presented in Table 4.6. The grand mean of producer responses to all WATT items was 3.5 (SD = 0.50) indicating a fairly neutral attitude towards water quality. Approximately 93% of respondents agreed with the statement that it was their personal responsibility to help protect water quality while 54% indicated water quality was the responsibility of the government. This possibility indicates a feeling among respondents that water quality management is a shared responsibility between the government and individual citizens. Nearly 79% of respondents agreed that care of personal property can impact water quality in lakes, rivers, and streams while over 85% agreed that improperly managed agricultural land can have negative consequences for water quality. Finally, 69% of respondents agreed that implementation of conservation practices can be profitable while nearly 68% of respondents disagreed that laws to protect water quality were unnecessary.

Table 4.6
Descriptive statistics for water quality attitude (WATT) statements.

Water Quality Attitude Statements	**SD**	**D**	**NAND**	**A**	**SA**	**Total**	
			%			***M***	***SD***
1. It is my personal responsibility to help protect water quality.	1.2	0.8	4.8	51.4	41.7	4.3	0.7
2. The government should pay farmers to implement practices that help protect water quality.	9.4	19.3	30.2	28.3	12.8	3.2	1.2
3. Laws intended to protect water quality are badly needed.	3.7	16.8	34.3	33.1	12.1	3.3	1.0
4. It is the responsibility of the government to help protect water quality.	6.0	15.5	24.2	42.4	11.8	3.4	1.1
5. The government should not be involved at all in agriculture.	11.9	35.6	29.0	15.6	7.8	3.3	1.1
6. Laws intended to protect water quality are unnecessary.	17.8	50.0	19.4	9.2	2.8	3.7	1.0
7. The way I care for my property can impact water quality in lakes, rivers, and streams.	3.3	7.1	10.7	57.8	21.1	3.9	0.9
8. Improperly managed agricultural land can have negative consequences for water quality.	1.2	4.5	9.1	64.9	20.3	4.0	0.8
9. What I do on my property doesn't have much impact on overall water quality.	9.5	41.6	14.7	28.9	5.3	3.2	1.1
10. Improperly managed agricultural land has minimal consequences for overall water quality.	12.9	54.8	14.9	14.5	2.9	3.6	1.0
11. Implementation of conservation practices can be profitable.	1.4	4.6	23.1	58.6	12.2	3.8	0.8
12. Taking action on my property to improve water quality is too expensive for me.	2.6	22.5	44.2	26.3	4.4	2.9	0.9
Total	—	—	—	—	—	**3.54**	**0.50**

Notes. SD = strongly disagree; D = disagree; NAND = neither agree nor disagree; A = agree; SA = strongly agree; *M* = mean; *SD* = standard deviation.

Items 2, 3, and 12 received the highest proportions of "neither disagree nor agree" responses. Thirty percent of respondents were unsure whether the government should pay farmers to implement practices that help protect water quality, 34% were uncertain whether laws to protect water quality were needed, and 44% were indecisive about water quality improvement actions being too expensive.

The internal consistency of both the NEP and WATT scales were assessed using the Cronbach (1957) alpha equation below. A larger value of alpha indicates inter-correlated scale items and, thus, a reliable "internal consistency" of the scale measure (Mueller 1986, Nunnally and Bernstein 1994). A coefficient alpha of $\alpha = 0.83$ was found for the NEP scale and a coefficient alpha of $\alpha = 0.74$ was found for the WATT scale indicating reasonable internal consistency of both scales.

$$\alpha = \frac{K}{K-1}\left(1 - \frac{\Sigma_{i=1}^{K}\sigma_{Y_i}^2}{\sigma_X^2}\right)$$

Where:

K = number of items in the scale

$\sigma_{Y_i}^2$ = variance of the responses for each item statement

σ_X^2 = variance of total test score

A paired sample *t*-test was conducted to evaluate whether respondents differed significantly on their NEP and WATT scores (Table 4.7). There was a significant difference between respondent mean NEP score ($M = 3.19$, $SD = 0.54$, $N = 737$) and WATT score ($M = 3.54$, $SD = 0.50$, $N = 738$), $t(736) = 16.45$, $p < 0.001$, 95% CI [0.302, 0.384] suggesting respondents held a more favorable attitude toward water quality than they did the environment in general.

Table 4.7
Descriptive statistics and results of paired samples *t*-test for respondent environmental attitude (EATT) and water quality attitude (WATT) scores.

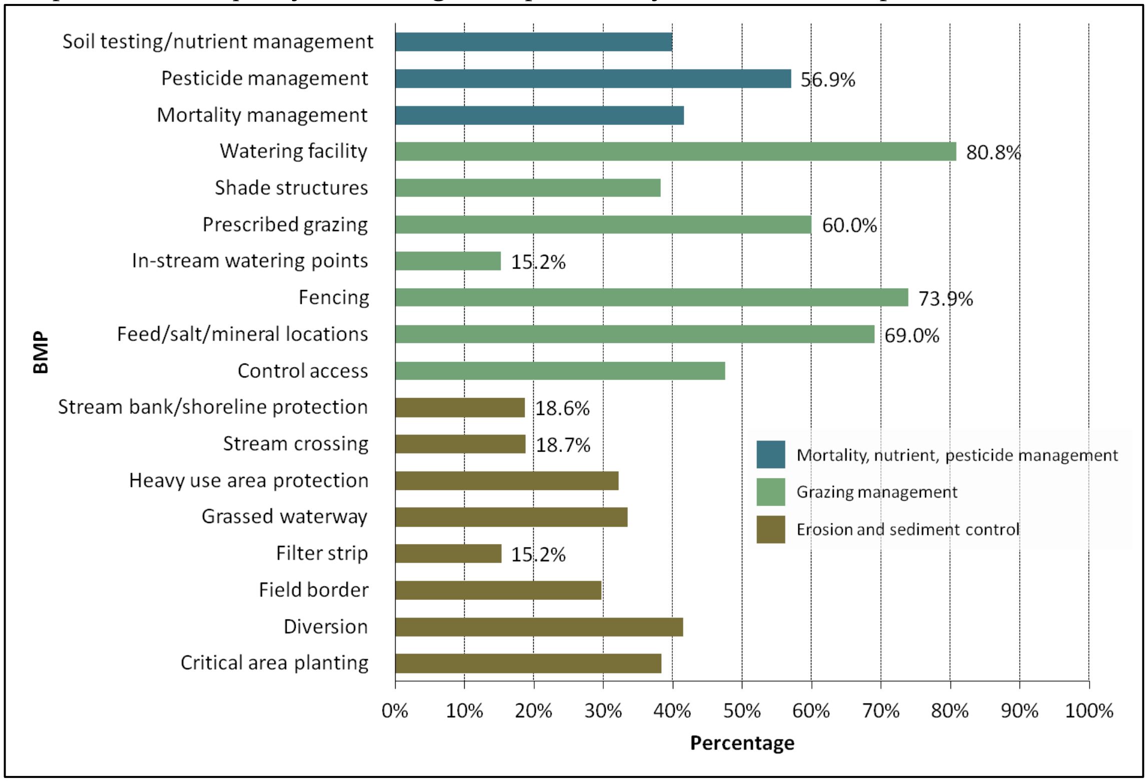
	EATT			WATT			95% CI for Mean Difference			
Outcome	***M***	***SD***	***N***	***M***	***SD***	***N***		***t***	***p***	***df***
	3.19	0.54	737	3.54	0.50	737	0.302, 0.384	16.45	.000	736

4.2. Research Question 1

Research question 1 sought to describe the current levels of adoption of water quality BMPs among Texas beef cattle producers (Figure 4.1). Respondents were asked to indicate whether they had adopted 18 different water quality BMPs by marking either yes or no for each practice. The most frequently adopted water quality BMPs were watering facilities (80.8% adoption) followed by fencing (73.9% adoption), feed/salt/mineral locations (69.0%) adoption), prescribed grazing (60.0% adoption), and pesticide management (56.9% adoption). All but the pesticide management practice fall within the broader category of grazing management BMPs, which represents the category with the highest number of adopted BMPs among respondents. This result is not surprising given our sample was comprised of beef cattle producers.

The least frequently adopted BMPs were in-stream water points (15.2% adoption), filter strips (15.2% adoption), stream bank/shoreline protection (18.6% adoption), and stream crossings (18.7% adoption). All but in-stream water points fall

Figure 4.1
Adoption of water quality best management practices by Texas beef cattle producers.



within the broader category of erosion and sediment control BMPs, which represents the category with the least number of adopted BMPs among respondents. The low frequency of adoption for these practices is likely due to the fact that only 35% of respondents reported having a stream running through their operation. The four practices listed above generally assume the presence of a stream on or near the property in order to be effectively implemented. Nonetheless, the very low adoption rates for filter strips was surprising given the substantial research suggesting their effectiveness in improving water quality and the National Conservation Buffer Initiative led by the NRCS that pledged to help landowners install 2 million miles of conservation buffers by 2002.

4.3. Research Question 2

Research question 2 sought to understand the current levels of maintenance of water quality BMPs among Texas beef cattle producers. For practices implemented, respondents were asked to rate their level of agreement with whether they had maintained the installed practice 5 years after implementation. Level of agreement was measured on a 5-point Likert Scale ranging from strongly disagree to strongly agree. Results for research question 2 are shown in Table 4.8.

Table 4.8
Descriptive statistics for agreement with BMP maintenance 5 years post implementation.

		SD	D	NAND	A	SA	Total	
BMP				*%*			***M***	***SD***
1.	Control access	0.0	0.3	15.9	69.9	13.9	4.0	0.6
2.	Critical area planting	0.0	0.4	16.3	70.0	12.9	3.9	0.6
3.	Diversion	0.0	0.4	14.3	70.1	15.1	4.0	0.6
4.	Field/salt/mineral location	0.0	0.2	15.2	69.2	15.4	4.0	0.6
5.	Fencing	0.0	0.8	13.2	65.5	20.5	4.1	0.6
6.	Field border	0.0	0.0	15.3	64.8	19.9	4.0	0.6
7.	Filter strip	0.0	1.2	11.8	69.4	17.6	4.0	0.6
8.	Grassed waterway	0.0	1.0	10.5	69.0	19.5	4.1	0.6
9.	Heavy use area protection	0.0	0.0	8.9	70.8	20.3	4.1	0.5
10.	In-stream water point	0.0	0.0	11.4	76.1	12.5	4.0	0.5
11.	Mortality management	0.4	0.8	10.9	69.5	18.4	4.0	0.6
12.	Pesticide management	0.3	0.0	10.1	65.6	24.0	4.1	0.6
13.	Prescribed grazing	0.0	0.3	8.7	70.4	20.6	4.1	0.5
14.	Shade structure	0.0	0.4	7.9	68.7	22.0	4.1	0.6
15.	Soil testing/nutrient mgmt.	0.9	1.6	8.9	68.5	20.2	4.1	0.7
16.	Stream bank/shoreline protect.	0.8	0.9	11.0	69.7	18.3	4.0	0.6
17.	Stream crossing	0.0	0.0	14.8	70.4	14.8	3.9	0.6
18.	Watering facility	0.4	0.2	8.6	65.3	25.6	4.0	0.6
Total		—	—	—	—	—	**4.0**	**0.50**

Notes. SD = strongly disagree; D = disagree; NAND = neither agree nor disagree; A = agree; SA = strongly agree; M = mean; SD = standard deviation.

Overall, respondents agreed they maintained all implemented practices for at least 5 years after implementation (*M* = 4.0, *SD* = 0.50). Regarding individual practice maintenance, the most maintained practices were heavy use area protection (91.1% agreement, *M* = 4.1, *SD* = 0.5), water facility (90.9% agreement, *M* = 4.0, *SD* = 0.6), and shade structures (90.7% agreement, *M* = 4.1, *SD* = 0.6). The least maintained practices, although by a very small margin, were control access (82.9% agreement, *M* = 4.0, *SD* = 0.6), critical area planting (83.8% agreement; *M* = 3.9, *SD* = 0.6), diversions (84.6% agreement, *M* = 4.0, *SD* = 0.6), and field/salt/mineral locations (84.7% agreement, *M* = 4.0, *SD* = 0.6).

This result differs from a National Institute of Food and Agriculture Conservation Effects Assessment Project (NIFA-CEAP) that assessed the "measurable effects of agricultural conservation practices on water quality" at 13 watershed project sites across the nation (Osmond et al. 2012, v). The study found 61% of management practices, 35% of structural practices, and 4% of planting practices were not maintained after adoption in one study watershed. The study also found a significant percentage of practices were not fully implemented even though farmers thought they were doing a good job. Consequently, our study participants may indeed be maintaining their installed practices or may believe they are maintaining the practices when in fact they are not.

4.4. Research Question 3

Research question 3 sought to evaluate the major barriers associated with the non-adoption of water quality best management practices by Texas livestock producers. Respondents were given a list of 13 different barriers and were asked to rank their level of agreement with whether the barrier prevented them from adopting one of the 18 different BMPs included in this study. Level of agreement was measured on a 5-point Likert Scale ranging from strongly disagree to strongly agree. Results for research question 3 are shown in Table 4.9.

Table 4.9
Descriptive statistics for agreement with barrier to adoption items for all respondents.

	SD	D	NAND	A	SA	Total	
Barrier Statement			*%*			***M***	***SD***
1. Weather factors uncertain at the time.	2.2	7.8	34.1	42	13.9	3.6	0.9
2. Did not have enough information about practice.	3.2	15.9	38.0	37.4	5.4	3.3	0.9
3. Practice cost too much out-of-pocket to implement.	3.2	13.9	42.5	35.0	5.4	3.3	0.9
4. Practice not applicable to my farm/ranch situation.	3.9	18.4	40.0	29.8	7.9	3.2	1.0
5. Was not able to see field demonstration of practice.	2.8	14.8	47.5	29.6	5.3	3.2	0.9
6. Uncertain practice would improve water quality.	4.1	19.9	45.9	26.8	3.2	3.1	0.9
7. Market conditions were unfavorable at the time.	3.7	17.5	54.3	21.6	2.8	3.0	0.8
8. Did not want to deal with additional management/labor of practice.	6.3	28.1	39.5	23.0	3.1	2.9	0.9
9. Practice not well-respected by other farmers/ranchers.	4.6	22.0	56.2	15.3	1.9	2.9	0.8
10. Did not have confidence in people/agencies providing info.	4.7	26.5	51.3	12.4	5.1	2.9	0.9
11. Did not think practice would be profitable.	6.3	29.2	41.9	19.4	3.2	2.8	0.9
12. Did not feel I had enough skill to implement practice.	5.5	28.2	44.2	20.3	1.8	2.8	0.9
13. Did not own land.	30.7	34.4	16.9	14.0	4.1	2.3	1.2
Total	—	—	—	—	—	**3.03**	**0.57**

Notes. SD = strongly disagree; D = disagree; NAND = neither agree nor disagree; A = agree; SA = strongly agree; M = mean; SD = standard deviation.

Nearly 56% of respondents agreed uncertain weather conditions prevented them from implementing a water quality BMP (*M* = 3.6, *SD* = 0.9) whereas nearly 43% of producers agreed not having enough information prevented them from implementing a practice (*M* = 3.3, *SD* = 0.9).

The lowest rated barriers were not owning land used for the operation (18.1% agreement, *M* = 2.3, *SD* = 1.2), not thinking the practice would be profitable (22.6% agreement, *M* = 2.8, *SD* = 0.9), not having enough skill to implement the practice (22.1% agreement, *M* = 2.8, *SD* = 0.9), not wanting to deal with the additional management/labor of an installed practice (25.1% agreement, *M*=2.9, *SD*=0.9), the practice not being respected by other farmers/ranchers (17.2% agreement, *M* = 2.8, *SD* = 0.9), and not having confidence in the agencies/people providing information about the practice (17.5% agreement, *M* = 2.9, *SD* = 0.9).

Items 8, 9, and 12 received the greatest proportion of "neither agree nor disagree" responses. Fifty-four percent of respondents were neutral on whether unfavorable market conditions were a barrier to practice implementation, 56% were neutral on whether the practice not being well-respected by other farmers/ranchers was a barrier to practice implementation, and 51% of respondents were neutral on whether low confidence in the agencies/people providing information about the practice was a barrier to practice implementation.

To determine the highest rated barriers for non-adopters of all 18 BMPs, a filter was created in the dataset so that only non-adopters of all 18 practices were included in the analysis. Descriptive statistics are presented in Table 4.10. The highest-rated barrier

Table 4.10
Descriptive statistics for agreement with barrier to adoption items for non-adopters of all 18 water quality best management practices.

	SD	D	NAND	A	SA	Total	
Barrier Statement			*%*			***M***	***SD***
1. Did not have enough information about practice.	0.0	3.0	39.4	42.4	15.2	3.70	0.77
2. Weather factors uncertain at the time.	0.0	6.3	34.4	46.9	12.5	3.66	0.79
3. Practice cost too much out-of-pocket to implement.	0.0	3.0	48.5	36.4	12.1	3.58	0.75
4. Was not able to see field demonstration of practice.	0.0	3.0	57.6	33.3	6.1	3.42	0.66
5. Practice not applicable to my farm/ranch situation.	0.0	11.8	50.0	23.5	14.7	3.41	0.89
6. Did not want to deal with additional management/labor of practice.	0.0	15.2	60.6	18.2	6.1	3.15	0.76
7. Did not think practice would be profitable.	3.0	18.2	45.5	30.3	3.0	3.12	0.86
8. Practice not well-respected by other farmers/ranchers.	0.0	6.1	81.8	6.1	6.1	3.12	0.60
9. Market conditions were unfavorable at the time.	0.0	9.1	75.8	12.1	3.0	3.09	0.58
10. Did not feel I had enough skill to implement practice.	3.0	12.1	60.6	24.2	0.0	3.06	0.70
11. Uncertain practice would improve water quality.	3.0	9.1	69.7	18.2	0.0	3.03	0.64
12. Did not have confidence people/agencies providing info.	3.1	18.8	65.6	9.4	3.1	2.91	0.73
13. Did not own land.	34.4	31.3	9.4	21.9	3.1	2.28	1.25
Total	—	—	—	—	—	**3.22**	**0.32**

Notes. SD = strongly disagree; D = disagree; NAND = neither agree nor disagree; A = agree; SA = strongly agree; *M* = mean; *SD* = standard deviation.

among non-adopters was not having enough information about the practice (M = 3.70, SD = 0.77) with nearly 58% of non-adopters agreeing this was a barrier to adoption. The next four highest-rated barriers included weather factors being uncertain (M = 3.66, SD = 0.79), the practice costing too much out-of-pocket (M = 3.58, SD = 0.75), not being able to see a field demonstration of the practice (M = 3.42, SD = 0.66), and the practice not being applicable to the farm/ranch situation (*M* = 3.41, *SD* = 0.89). The lowest-rated barriers among non-adopters were not owning the land (*M* = 2.28, *SD* = 1.25) and not having confidence in the people or agencies providing information about the practice (*M* = 2.91, *SD* = 0.73).

To determine whether the means of individual barrier statements differed for adopters and non-adopters, an independent sample *t*-test was conducted with the 13 barrier statements (Q11A-Q11M) included as test variables and ADOPTION (0 = non-adopter, 1 = adopter) included as the grouping variable (Table 4.11). The variable ADOPTION was created by assigning a 1 to all respondents who indicated they had adopted at least one of the 18 practices included in the study; a 0 was assigned to all other respondents. Corrections for multiple comparisons were assessed using the Bonferonni correction (Keppel and Sedeck 1989). The only significant differences between adopters and non-adopters occurred for barrier statement 7 (I did not feel I had enough skill to implement practice, $t(81.89) = 2.16$, $p = 0.034$) and statement 9 (practice not well-respected by other farmers/ranchers, t(86.23 = 2.09, $p = 0.040$) with non-adopters rating these as greater barriers than adopters.

To determine whether grand mean scores of all 13 barrier statements differed among key demographic and producer characteristic groups, a factorial between-subjects analysis of variance (ANOVA) was conducted with the grand mean score (BMP_BAR_GrandMean) included as the dependent variable and gender (Q15), education (Q17), salary (Q29), age (AGE_GROUP), and acreage (ACREAGE_GROUP) included as fixed factors. Results are presented in Table 4.12.

Table 4.11
Descriptive statistics and results from independent samples *t*-test for individual barrier item score by adopters and non-adopters of water quality best management practices.

Barrier Statement	***N***	***M***	***SD***	***t***	***p***
1. Did not own land used for operation.	—	—	—	—	—
Non-adopter	66	2.24	1.14	-0.16†	0.87
Adopter	615	2.27	1.16	—	—
2. Did not think practice would be profitable.	—	—	—	—	—
Non-adopter	66	2.98	0.89	1.38	0.17
Adopter	619	2.83	0.92	—	—
3. Did not want to deal with additional mgmt.	—	—	—	—	—
Non-adopter	65	3.00	0.81	1.20	0.24
Adopter	614	2.87	0.95	—	—
4. Did not have enough info. about practice.	—	—	—	—	—
Non-adopter	66	3.44	0.84	1.72†	0.09
Adopter	618	3.24	0.91	—	—
5. Uncertain practice would improve water quality.	—	—	—	—	—
Non-adopter	65	3.09	0.81	0.40†	0.69
Adopter	613	3.05	0.88	—	—
6. Practice cost too much out-of-pocket.	—	—	—	—	—
Non-adopter	66	3.30	0.56	0.47†	0.64
Adopter	617	3.25	0.88	—	—
7. Did not feel I had enough skill to implement practice.	—	—	—	—	—
Non-adopter	65	3.05	0.78	2.16	0.03*
Adopter	620	2.82	0.88	—	—
8. Market conditions unfavorable at the time.	—	—	—	—	—
Non-adopter	66	3.11	0.66	1.04	0.30
Adopter	613	3.01	0.82	—	—
9. Practice not well-respected by other farmers/ranchers.	—	—	—	—	—
Non-adopter	66	3.05	0.67	2.09	0.04*
Adopter	615	2.86	0.80	—	—
10. Practice not applicable to farm/ranch.	—	—	—	—	—
Non-adopter	67	3.36	0.93	1.48†	0.14
Adopter	628	3.18	0.96	—	—
11. Weather factors uncertain at time.	—	—	—	—	—
Non-adopter	65	3.46	0.85	-1.09†	0.28
Adopter	625	3.59	0.91	—	—
12. Did not have confidence in people providing info.	—	—	—	—	—
Non-adopter	65	2.91	0.68	0.49	0.63
Adopter	621	2.86	0.89	—	—
13. Was not able to see field demonstration of practice.	—	—	—	—	—
Non-adopter	66	3.24	0.70	0.53	0.60
Adopter	616	3.19	0.87	—	—

Notes. Scale = 1 for strongly disagree to 5 for strongly agree with 3 being neither agree nor disagree.
† Equal variances assumed based on Levene’s Test for Equality of Variances.
* Significant at $p = 0.05$.

Table 4.12
Descriptive statistics and analysis of variance results for grand mean scores on all 13 barrier items related to best management practice adoption by age, acreage, sex, education, and salary.

Variable	***M***		***SD***	***N***
Age	—		—	—
Less than 30	3.02		0.46	4
30-49	3.10		0.58	89
50-69	2.99		0.58	409
Older than 70	3.06		0.58	225
Acreage	—		—	—
Less than 25	2.99		0.51	60
26-100	2.99		0.54	150
101-250	3.13		0.52	142
251-500	2.93		0.57	115
501-1000	3.10		0.61	94
1001-2500	3.07		0.49	68
More than 2500	2.97		0.74	86
Sex	—		—	—
Male	3.02		0.57	630
Female	3.05		0.61	94
Education	—		—	—
Less than high school	3.24		0.69	22
High school/GED	3.00		0.59	164
Some college/technical degree	3.05		0.57	233
College Bachelor’s degree	3.03		0.58	176
Advanced degree	2.99		0.53	134
Annual Salary	—		—	—
Less than $30,000	3.07		0.55	116
$30,000-$59,999	3.04		0.55	176
$60,000-$89,999	2.99		0.62	142
$90,000-$119,999	2.98		0.46	82
More than $120,000	3.02		0.64	158
Source	***SS***	***df***	***MS***	***F***
Age	1.36	3	0.46	1.25
Acreage	3.67	6	0.61	1.68
Sex	0.00	1	0.00	0.01
Education	1.55	4	0.39	1.06
Annual Salary	0.44	4	0.11	0.30
Error	4016.05	652	0.37	—

Notes. Scale = 1 for strongly disagree to 5 for strongly agree with 3 being neither agree nor disagree.

There were no significant main effects of gender [F(1, 652 =0.011, p = 0.916], education [F(4, 652 = 1.06, p = 0.374], salary [F(4, 652 = 0.298, p = 0.879], age [F(3, 652 = 1.25, p = 0.292], or acreage [$F(6, 652) = 1.68$, p = .0124]. Given the number of fixed factors included in the ANOVA, interaction effects were not analyzed.

4.5. Research Question 4

Research question 4 sought to evaluate the major barriers associated with non-participation in a government cost-share program by Texas livestock producers. Respondents were given a list of 6 different barrier items and were asked to rank their level of agreement with each item being a barrier to their participation in a government cost-share program such as EQIP, WHIP, etc. Level of agreement was measured on a 5-point Likert scale ranging from strongly disagree to strongly agree. Results for research question 4 are shown in Table 4.13.

Table 4.13
Descriptive statistics for agreement with barrier items related to participation in a government cost-share program (N=715).

	SD	D	NAND	A	SA	Total	
Barrier Statement	*%*	*%*	*%*	*%*	*%*	***M***	***SD***
1. Funding provided by the program was inadequate.	1.8	11.3	58.5	22.4	6.0	3.2	0.8
2. Practice standard did not allow enough flexibility in practice design.	1.0	9.7	56.1	26.3	6.8	3.3	0.8
3. Too many requirements (red tape) of the government program.	0.7	9.2	42.2	32.7	15.2	3.5	0.9
4. Too much time required to work through the application process.	0.9	13.5	52.2	25.1	8.3	3.3	0.8
5. Worried about flexibility to change land use practices in the future.	0.9	10.6	47.0	30.4	11.1	3.4	0.9
6. Had difficulty understanding the program requirements.	2.1	18.3	55.5	20.2	4.0	3.1	0.8
Total	—	—	—	—	—	**3.29**	**0.61**

Notes. SD = strongly disagree; D = disagree; NAND = neither agree nor disagree; A = agree; SA = strongly agree; M = mean; SD = standard deviation.

The highest-rated barriers to participation in a government-funded cost-share program were the requirements (red tape) involved (47.9% agreement, *M* = 3.5, *SD* = 0.9) and the potential loss of long-term flexibility in land use practices after practice implementation (41.5% agreement, *M* = 3.4, *SD* = 0.9). The lowest-rated barriers to participation in a government cost-share program were not understanding program requirements (24.2% agreement, *M* = 3.1, *SD* = 0.8) and inadequate conservation program funding (28.4% agreement, *M* = 3.2, *SD* = 0.8). All but 2 of the barrier statements (items 3 and 5) received more than 50% of "neither agree nor disagree" responses. One potential contributor to this is the fact that only 31% of respondents indicated they had participated in a government-funded cost-share program.

To determine whether the means of individual barrier statements and the grand mean of all 6 statements differed for those who had and those who had not participated in a government-funded cost-share program, an independent samples *t*-test was conducted with the 6 barrier statements (Q13A-Q13F) and the grand mean (GCS_BAR_GrandMean) included as test variables and Q12 (have you ever participated in a government funded cost-share program; 0 = no, 1 = yes) included as the grouping variable (Table 4.14). For all comparisons, a separate estimate of variance was used because variances between the two groups were not homogenous. Corrections for multiple comparisons were assessed using the Bonferonni correction (Keppel and Sedekck 1989). There were no significant differences between groups for item 1 (amount of funding provided by program was inadequate, $t(303.2) = -1.55$, $p = 0.099$), item 2 (government practice standard did not allow enough flexibility in practice design and implementation, $t(310.9) = -0.67$, $p = 0.506$), item 3 (too many requirements of the government program, $t(333.1) = 0.934$, $p = 0.351$), and item 5 (worried about possible interference with my flexibility to change land use practices in the future, $t(331.4) = 1.14$, $p = .257$).

Table 4.14
Descriptive statistics and results from independent samples *t*-test for individual barrier item and grand mean score by participants and non-participants in a government cost-share program (GCSP).

Barrier Statement	***N***	***M***	***SD***	***t***	***p***
1. Funding provided by the program was inadequate.	—	—	—	—	—
No participation in GCSP†	448	3.16	.665	-1.66	-0.99
Participation in GCSP	212	3.28	.995	—	—
2. Practice standard did not allow enough flexibility in	—	—	—	—	—
practice design.	—	—	—	—	—
No participation in GCSP†	444	3.27	.663	-0.67	-.506
Participation in GCSP	213	3.31	.966	—	—
3. Too many requirements (red tape) of the government	—	—	—	—	—
program.	—	—	—	—	—
No participation in GCSP†	449	3.55	.795	0.93	.351
Participation in GCSP	214	3.48	1.05		
4. Too much time required to work through the	—	—	—	—	—
application process.	—	—	—	—	—
No participation in GCSP†	445	3.36	.739	3.45	.001*
Participation in GCSP	211	3.09	.981	—	—
5. Worried about flexibility to change land use practices	—	—	—	—	—
in the future.	—	—	—	—	—
No participation in GCSP†	444	3.44	.768	1.14	.257
Participation in GCSP	213	3.35	1.02	—	—
6. Had difficulty understanding the program	—	—	—	—	—
requirements.	—	—	—	—	—
No participation in GCSP†	446	3.20	.701	6.26	.000**
Participation in GCSP	213	2.77	.901	—	—
7. Grand Mean	—	—	—	—	—
No participation in GCSP†	453	3.34	.533	2.04	.042*
Participation in GCSP	215	3.22	.748	—	—

Notes. Equal variances not assumed; scale = 1 for strongly disagree to 5 for strongly agree with 3 being neither agree nor disagree.
† GCSP stands for government-funded cost-share program.
* Significant at $p = 0.05$.
** Significant at $p < 0.001$.

There were significant differences between groups for item 4 (too much time required to work through application process, $t(326.9) = 3.45$, $p = 0.001$) and item 6 (difficulty understanding program requirements, $t(338.5) = 6.23$, $p < 0.001$) with those having never participated in a government cost-share program rating these as greater barriers as compared to those who had previously participated in a cost-share program. There were also significant differences between groups for the grand mean of all items, $t(323.4) = 2.04$, $p = 0.042$) with those having never participating in a government cost-share program having a higher grand mean score than those who had.

To determine whether grand mean scores of all 6 barrier statements differed among key demographic and producer characteristic groups, a factorial between-subjects analysis of variance (ANOVA) was conducted with the grand mean score (GSC_BAR_GrandMean) included as the dependent variable and gender (Q15), education (Q17), salary (Q29), age (AGE_GROUP), and acreage (ACREAGE_GROUP) included as fixed factors. Descriptive statistics and ANOVA results are presented in Table 4.15.

There was a significant main effect of gender [F(1, 598 = 4.05, p = 0.045] with males having a higher overall barrier score than females. There were no significant main effects for education [F(4, 598 = 1.003, p =0.405], salary [F(4, 598 = 1.342, p = 0.253], age [F(3, 598 = 794, p =0 .498], or acreage [F(6, 598) = 1.088, p = 0.368]. Given the number of fixed factors included in the ANOVA, interaction effects were not analyzed.

Table 4.15
Descriptive statistics and analysis of variance results for grand mean scores on all 6 barrier items related to participation in a government-funded cost-share program by age, acreage, sex, education, and salary.

Variable	***M***		***SD***	***N***
Age	—		—	—
Less than 30	3.04		0.08	4
30-49	3.27		0.55	89
50-69	3.33		0.63	409
Older than 70	3.26		0.60	225
Acreage	—		—	—
Less than 25	3.15		0.49	60
26-100	3.29		0.52	150
101-250	3.30		0.56	142
251-500	3.25		0.61	115
501-1000	3.33		0.64	94
1001-2500	3.43		0.68	68
More than 2500	3.29		0.72	86
Sex	—		—	—
Male	3.30		0.61	630
Female	3.22		0.58	94
Education	—		—	—
Less than high school	3.38		0.80	22
High school/GED	3.29		0.60	164
Some college/technical degree	3.29		0.57	233
College Bachelor's degree	3.27		0.61	176
Advanced degree	3.33		0.65	134
Annual Salary	—		—	—
Less than $30,000	3.27		0.57	116
$30,000-$59,999	3.24		0.58	176
$60,000-$89,999	3.28		0.58	142
$90,000-$119,999	3.24		0.59	82
More than $120,000	3.41		0.67	158
Source	***SS***	***df***	***MS***	***F***
Age	0.867	3	0.289	0.794
Acreage	2.378	6	0.396	1.088
Sex	1.473	1	1.473	4.045*
Education	1.462	4	0.365	1.003
Annual Salary	1.954	4	0.489	0.342
Error	217.77	598	0.364	—

Notes. Scale = 1 for strongly disagree to 5 for strongly agree with 3 being neither agree nor disagree.
* Significant at p=0.05.

4.6. Research Question 5

4.6.1. Tests for Multicollinearity

Research question 5 sought to determine how capacity, attitudes, environmental awareness, and farm characteristics of Texas beef cattle producers influence the adoption behavior of water quality best management practices. Multicollinearity among the 30 variables hypothesized as important in determining beef cattle producers' decisions to adopt water quality BMPs was first analyzed using the collinearity diagnostics option found under linear regression in SPSS. Several methods can be used to check for the presence of multicollinearity. The first method is to examine the tolerance and variance inflation factor (VIF) collinearity statistics. A tolerance value of less than 0.10 or a VIF value greater than 10 suggests serious multicollinearity problems (Pallant 2007). Summary of the results (Appendix H) showed that none of the 30 independent variables had tolerance values less than 0.10 or VIFs greater than 10 suggesting no serious multicollinearity problems exist among the predictor variables.

The second method to examine multicollinearity is to assess the collinearity diagnostics. Collinearity diagnostics consist of eigenvalues (λ_i), condition indices (η_i), and the proportion of variation matrix. The first step is to identify all condition indices with values greater than 30 (Uli et al. 2011). Then, for all condition indices that exceed this threshold value, all variables with variance proportions above 0.90 are identified. A collinearity problem is indicated when a condition index value above 30 accounts for a substantial proportion of variance (0.90 or above) for two or more coefficients (Hair et al. 1998). Summary of the results (Appendix H) showed two condition index values that exceeded the threshold value of 30 (last 2 rows in collinearity diagnostic table). However, no variance proportion values in these rows exceeded the threshold of 0.90 suggesting no serious multicolinearity problems exist among the 30 predictor variables. Consequently, all 30 predictor variables were included in the base model for the univariate probit analysis of each individual water quality BMP.

4.6.2. Results of Univariate Probit Analyses

Summary statistics for all explanatory variables included in the probit analyses are presented in Table 4.16. Results of the 18 univariate probit models are discussed below. Marginal effects for each independent variable influencing adoption of each of the 18 BMPs are presented in Table 4.17.

4.6.2.1. Attitudinal Variables

As described in Table 4.16, the attitudinal construct was comprised of 5 different variables. Environmental attitude (EATT) and water quality attitude (WATT) were significant predictors of adoption for only 3 of the included practices. Higher EATT and WATT scores denote greater pro-ecological or environmental perspectives. According to the results, a one unit increase in EATT scores would increase the probability of adopting feed/salt/mineral locations by 13.1% and field borders by 12.9%. A one unit increase in WATT scores would increase the probability of adopting in-stream watering points by 13.1%. The lack of more significant impacts of EATT and WATT on producer adoption behavior is likely due to the fact that grand mean EATT and WATT scores were $M = 3.19$ and $M = 3.54$, respectively suggesting very neutral attitudes among respondents with regard water quality and environmental attitudes.

Table 4.16
Summary statistics for explanatory variables included in probit analyses.

Variable	Description	*M*	*SD*
Attitude		—	—
EATT	Summated score on NEP scale	—	—
WATT	Summate score on water quality attitude scale	—	—
Q12	Prior participation in government cost-share program	0.31	0.464
Q24_RCD	Dummy for whether any family plans to take over farm	—	—
Q33_RCD	Dummy for risk-averse operator	—	—
Capacity		—	—
AGE	Age of operator	62.90	11.700
Q1_RC	Dummy for livestock diversity	0.37	0.482
Q2_RC	Dummy for crop diversity	0.18	0.385
Q17_RCD	Dummy for holding a college bachelor's degree	0.42	0.495
Q23_RCD	Dummy for family members working on farm	0.60	0.490
Q21	Number of years running livestock operation	25.90	21.400
Q22	Number of years planning to run operation into future	38.70	409.220
Q29	Annual income (1-5 scale treated as continuous)	2.13	1.408
Q30	% operation income (1-5 scale treated as continuous)	2.04	0.955
Q31	% off-farm income (1-5 scale treated as continuous)	4.42	1.863
Q25_RCD	Dummy for visits with Extension	0.40	0.490
Q26_RCD	Dummy for visits with NRCS	0.33	0.472
Q34	Member of Texas livestock organization	0.24	0.425
Environmental Awareness			
Q4	Knowledge of term best management practice	0.50	0.500
Q5	Knowledge of term nonpoint source pollution (NPS)	0.23	0.422
Q6	Knowledge of bacteria as major cause of impairment	0.37	0.484
Q7	Knowledge of Clean Water Act to control NPS	0.31	0.462
Q8	Knowledge of financial assistance programs for NPS	0.15	0.362
Q36_RCD	Dummy for rating of water quality in area	0.49	0.500
Farm Characteristics		—	—
Q15	Male/female	0.13	0.341
Q19	Total acreage in operation	1864.90	6539.590
OWN_PER	Ratio of land owned to total land operated	0.84	1.059
RENT_PER	Ratio of land rented to total land operated	0.33	0.399
Q32_RC	Dummy for debt-asset ratio	0.08	0.279
Q35_RCD	Dummy for nearest water body to operation	0.35	0.478

Table 4.17
Marginal effects of probit analyses on the adoption of best management practices by Texas beef cattle producers.

Variables	Control Access	Critical Area Planting	Diversion	Field/Salt/Mineral Location	Fencing	Field Border
Q4	0.18604***	0.07177	0.01963	0.03225	0.18776***	0.02701
Q5	-0.09721	-0.02867	-0.01131	0.00562	0.06234	0.09916
Q6	0.0443	0.04289	-0.03948	0.06133	-0.00211	0.00595
Q7	0.03836	0.00502	0.07893	-0.00903	-0.05079	0.06998
Q8	0.04705	0.08638	0.05863	0.14980*	0.13389*	0.02349
Q12	0.15368*	0.27715***	0.1172	-0.10909	0.00018	0.15474*
Q15	-0.08529	-0.16547*	-0.10613	0.03176	-0.02816	-0.25283***
AGE	-0.00376	-0.00468	-0.00224	0.00516	-0.00088	-0.00264
Q19	-0.36316D-05	-0.66042D-05	-0.55481D-05	0.22655D-04	-0.22683D-05	0.21423D-05
Q21	-0.00102	0.00064	0.00121	0.00123	0.00332*	0.00073
Q22	-.85246D-05	-0.57534D-04	0.83654D-04	-0.34478D-04	0.00057	-0.35875D-04
Q29	-0.00921	0.0271	0.08025***	0.03117	0.04483*	0.06792**
Q30	0.07612*	0.06313	0.15372***	0.11617**	0.10165**	-0.00022
Q31	0.00794	0.00924	0.09945***	0.01366	0.00985	0.00264
Q34	0.02538	0.02337	-0.10546	-0.03118	0.13616*	-0.08395
WATT	0.01744	0.0638	-0.03128	-0.05825	-0.07793	-0.03732
EATT	0.12204	0.03444	0.04068	0.13139*	0.03833	0.12895*
Q17_RCD	-0.01671	-0.10766	-0.13208**	0.05675	0.01494	-0.03785
Q23_RCD	-0.02016	0.13222*	-0.0916	0.05034	0.03939	-0.0611
Q25_RCD	0.26535***	0.11377	0.10481	0.20103***	0.03595	0.05437
Q26_RCD	-0.14548*	-0.21964***	-0.02885	-0.05984	-0.04895	-0.13627*
Q33_RCD	-0.04783	-0.10608	-0.07525	-0.08121	-0.03761	-0.12874*
Q35_RCD	0.02421	0.08553	0.06919	0.01044	-0.04032	-0.01088
Q36_RCD	0.10051	-0.02556	-0.09028	0.02153	0.00448	-0.0245
Q1_RC	0.19898***	0.02882	0.07176	-0.03463	0.04335	0.00956
Q2_RC	0.04685	0.15577*	0.25822***	0.12103	0.03496	0.26962***
OWN_PER	-0.14031	-0.01093	-0.07976	-0.03901	0.00378	0.09425
RENT_PER	0.02919	0.05353	-0.0248	0.09643	0.03078	0.11836
Q32_RC	0.02181	-0.01004	0.07930*	0.05753	0.01336	0.01202
Q24_RCD	0.00794	-0.06488	-0.12644*	-0.01883	0.00737	-0.10172
Observations	187	190	183	186	192	183
McFadden's R^2	0.226	0.166	0.257	0.223	0.166	0.222
% Correctly Predicted	63.64	62.11	66.67	67.74	67.71	67.76

*** Values significant at 1% level
** Values significant at 5% level
* Values significant at 10% level.

Table 4.17 Continued

Variables	Filter Strip	Grassed Waterway	Heavy Use Area Protection	In-Stream Watering Point	Mortality Management	Pesticide Management
Q4	-0.01349	-0.06889	0.01238	-0.08579	-0.01836	0.01837
Q5	0.15969*	0.03585	-0.01137	-0.06982	0.12797	0.14329
Q6	-0.00317	-0.03907	0.02926	-0.00385	0.02938	0.04935
Q7	0.10517	0.12233	0.01075	0.0979	0.06781	0.11779
Q8	0.0591	-0.02749	0.06093	0.00012	0.01167	0.00064
Q12	0.07881	0.23535**	0.14730*	0.23427***	0.15461	-0.06162
Q15	0.04725	-0.22411***	-0.19722***	-0.13075***	0.07757	0.01037
AGE	-0.00111	-0.00291	0.00264	0.00141	-0.00363	0.00673*
Q19	0	-0.47851D-05	0.34714D-06	0	-0.18370D-05	-0.70658D-05
Q21	0.00116	-0.00086	0.72647D-04	0.00132	0.00232	-0.00183
Q22	0.61147D-05	-0.48194D-04	-0.21401D-04	0.15177D-04	-0.00029	0.87509D-04
Q29	0.00885	0.06734***	0.08123***	0.0076	0.03385	0.02237
Q30	0.0019	0.09998***	0.06739	0.0468	0.03916	0.15130***
Q31	0.03395	0.02202	0.05066*	0.06416*	0.05839*	0.03661
Q34	-0.09520**	-0.18691***	-0.11765*	-0.03846	0.02328	-0.03321
WATT	-0.00045	0.01742	0.02587	0.13081**	0.03172	-0.08832
EATT	-0.05586	0.05421	0.02948	0.05072	-0.03021	0.07291
Q17_RCD	-0.02197	-0.02763	-0.05242	-0.03294	-0.06127	-0.00366
Q23_RCD	0.09157*	0.01409	0.0379	0.04662	-0.1046	0.02576
Q25_RCD	0.12030**	0.09988	0.13321*	0.02885	0.07182	0.26099***
Q26_RCD	-0.09891	-0.10002	-0.07934	-0.17530***	-0.11405	-0.09343
Q33_RCD	0.06103	0.09455	-0.084	-0.04092	-0.20688***	-0.10543
Q35_RCD	0.01255	0.01742	-0.05039	0.19604***	0.02549	-0.15105**
Q36_RCD	0.008	-0.03311	0.02253	0.09656*	-0.06159	0.0635
Q1_RC	-0.00101	0.00205	0.10778	0.02168	-0.00081	-0.03062
Q2_RC	0.19528***	0.24827***	0.03005	0.15787**	0.10899	0.25285***
OWN_PER	0.02545	-0.12726	-0.01413	-0.09659	-0.21095	-0.00325
RENT_PER	-0.06376	-0.09986	-0.24001	-0.14358	-0.2594	-0.14055
Q32_RC	0.02195	0.028	-0.00572	0.05428*	0.04377	0.03991
Q24_RCD	-0.14960***	-0.00043	-0.16730***	-0.09087*	-0.00278	0.04429
Observations	181	184	183	181	185	186
McFadden's R^2	0.311	0.268	0.206	0.359	0.186	0.237
% Correctly Predicted	83.42	70.65	68.31	82.32	64.32	63.44

*** Values significant at 1% level
** Values significant at 5% level
* Values significant at 10% level.

Table 4.17 Continued

Variables	Prescribed Grazing	Shade Structure	Soil Testing	Stream bank/ Shoreline Protection	Stream Crossing	Watering Facility
Q4	0.12960*	-0.01896	0.17542**	0.04082	0.05346	0.01957
Q5	-0.0532	-0.07284	-0.08394	0.0863	0.10848	0.14152**
Q6	-0.02111	-0.08173	-0.04946	0.04111	0.08191*	0.15127***
Q7	0.1025	-0.02045	0.10835	0.06155	0.00906	-0.00778
Q8	-0.01957	0.00585	0.0886	0.04186	0.19269**	-0.04654
Q12	0.24112***	-0.04283	0.09222	0.06735	-0.00276	0.10196
Q15	-0.12365	-0.15093*	-0.02668	0.16463	-0.02268	0.01808
AGE	0.00498	0.01265***	0.00627	0.0026	0.00065	0.00591*
Q19	-0.73692D-05	-0.96817D-06	-0.85678D-05	0.13702D-05	0.47878D-06	0.11551D-04
Q21	0.00414*	0.18070D-05	-0.00347	0.0002	0.0016	-0.00162
Q22	-0.47208D-04	-0.00018	-0.51548D-04	-0.18757D-04	0.00024	0.00048
Q29	-0.01391	0.03985	0.03787	0.06081**	0.02867	0.04319*
Q30	0.10236**	0.09364**	0.05471	0.03659	-0.00764	0.06274
Q31	0.03406	0.01606	0.03932	-0.0023	0.00308	0.03452*
Q34	0.02734	-0.14171*	0.00309	-0.10444**	0.0124	-0.02451
WATT	0.0029	-0.08539	0.00986	0.06091	0.0347	-0.08334
EATT	0.01857	0.04406	-0.02473	-0.03767	-0.04407	0.05411
Q17_RCD	-0.1128	-0.02332	-0.15342**	-0.03376	-0.00523	-0.07306
Q23_RCD	-0.00738	0.17349***	-0.01143	0.0233	0.07114	0.00254
Q25_RCD	0.09339	0.0094	0.38781***	0.08722	0.12049**	0.00973
Q26_RCD	-0.05622	-0.11412	-0.10123	-0.07693	-0.08074	-0.08673
Q33_RCD	-0.10059	0.13352*	-0.00504	-0.03983	0.09447*	0.00429
Q35_RCD	-0.05604	-0.13820**	-0.00603	0.09845	0.07478	-0.14212**
Q36_RCD	-0.07946	-0.17522***	0.08509	0.07107	0.00735	-0.10260*
Q1_RC	0.12691	0.08407	-0.03519	-0.07904	0.01437	0.12419*
Q2_RC	0.13075	0.05959	0.21739***	-0.00982	0.13547*	0.0616
OWN_PER	-0.12404	0.08398	0.04522	-0.16643	0.00554	0.05724
RENT_PER	0.04955	0.20689	0.16527	-0.10999	-0.01244	0.17215
Q32_RC	-0.02432	0.04917	0.00229	-0.03674	-0.01135	-0.02519
Q24_RCD	0.0821	0.08752	-0.05226	-0.03995	-0.06367	0.06437
Observations	186	181	182	180	175	189
McFadden’s R^2	0.171	0.213	0.266	0.309	0.327	0.179
% Correctly Predicted	62.37	66.85	67.03	80.00	84.00	72.49

*** Values significant at 1% level
** Values significant at 5% level
* Values significant at 10% level

Prior participation in a government-funded cost-share program (Q12) significantly impacted adoption for 7 out of the 18 practices. These practices were control access, critical area planting, field borders, grassed waterways, heavy use area protection, in-stream watering points, and prescribed grazing. The greatest increases in probabilities were seen for critical area planting and prescribed grazing. Prior participation in a government-funded cost-share increased the probability of adopting critical area planting by 27.7% and prescribed grazing by 24.1%. Prior participation had the least impact on the adoption of heavy use area protection, only increasing the probability of adoption by 14.7%.

Having a family member planning to take over the operation upon the producer's retirement (Q24_RCD) was unexpectedly and significantly negatively associated with the adoption of diversions, filter strips, heavy use area protection, and in-stream watering points. Diversions and filter strips might not have been broadly applicable for our sample as diversions are generally prescribed for concentrated animal feeding operations and filter strips are predominantly used on croplands. However, this variable was negatively associated (although not significant in all cases) with the adoption of 12 out of the 18 BMPs included in the study. Kim et al. (2005) found similar negative associations, but failed to provide an explanation. A potential explanation in this study stems from the growing trend of agricultural land in Texas changing hands to a younger generation who may not be inclined to rely solely on agricultural production for income. A significant portion of this land is being managed for recreational purposes, which may preclude adoption of several agricultural BMPs.

The producer's tendency to avoid risk (Q33_RCD) was unexpectedly and significantly negatively associated with the adoption of field borders and mortality management, but positively associated with the adoption of shade structures and stream crossings. Stated differently, risk aversion reduced the probability of adopting field borders by 12.9% and mortality management by 20.7%. In fact, risk aversion was negatively associated (although not significant in all cases) with the probability of adopting 13 out of the 18 BMPs included in the study; one might expect just the opposite to be true. Kim et al. (2005) found this negative association in their study as well and attributed it to the fact that risk averse producers require sufficient information about the costs and benefits associated with the adoption of both management-intensive and capital-intensive practices prior to implementation. Field borders and mortality management might not have been broadly applicable to our study participants given field borders are generally predominantly used on croplands and mortality management practices are more applicable for concentrated animal feeding operations. In addition, both practices could both be considered management-intensive, and even capital-intensive, practices suggesting beef cattle producers did not have enough information about the costs and benefits associated with these practices prior to implementation.

4.6.2.2. Capacity Variables

Operator age (AGE) was positively associated with the adoption of pesticide management, shade structures, and watering facilities. This result differs from most of the literature pertaining to conservation practice adoption, which generally concludes older producers have shorter planning horizons and, therefore, often choose not to adopt practices. However, one possible explanation is provided by Basarir (2002), who found that older beef cattle producers value land conservation and maintenance and are, therefore, more prone to adopt practices that will maintain and conserve their land. It is also worth noting that pesticide management and shade structures are relatively less capital-intensive BMPs, possibly indicating the "shorter planning horizon" hypothesis might not necessarily apply. Concerning watering facilities, which are generally more capital-intensive, older producers may be implementing this practice because they have greater financial resources than younger producers. It is also worth noting that pesticide management, shade structures, and watering facilities are all practices with direct observable benefits to cattle production, a characteristic that older producers may find more appealing.

Livestock (Q1_RC) and crop diversity (Q2_RC) were both positively associated with the adoption of several BMPs. Raising more than one type of livestock (i.e., in addition to beef cattle) increased the probability of adopting a watering facility by 12.4% and control access by 19.9%. Crop diversity (i.e., growing more than one type of crop in addition to raising beef cattle) increased the probability of adopting critical area planting by 15.6%, diversions by 25.8%, field borders by 26.9%, filter strips by 19.5%, grassed waterways by 24.8%, in-stream watering points by 15.8%, pesticide management by 25.2%, soil testing/nutrient management by 21.7%, and stream crossings by 13.6%. The association of crop diversity with the adoption of these BMPs is interesting given the majority of BMPs in this list are vegetated practices that would likely require the same type of equipment used for planting crops. In addition, management practices including pesticide and nutrient management are likely practices already in use by the landowner for the purposes of planting and growing crops. These results follow prior research, which suggests producers with diverse operations are more likely to experiment with new innovations and that this diversity qualifies the landscape for a wider variety of BMPs (Rahelizatavo and Gillespie 2004).

Having a bachelor's degree or greater (Q17_RCD) was negatively associated with the adoption of diversions, field borders, and soil testing/nutrient management. In fact, this variable was negatively associated (although not significant in all cases) with the adoption of 16 out of the 18 BMPs included in the study. This result was completely unexpected given the conservation practice adoption literature generally agrees that some level of college education is positively associated with conservation practice adoption. In one study, however, Banerjee et al. (2009) found college education to be insignificantly associated with the adoption of conservation-tillage practices and herbicide-resistant seed in cotton production. No explanation was given as to the potential nature of this relationship. One possible interpretation of the negative relationship between formal education and adoption among Texas beef cattle producers may be that producers with a college education have professional off-farm jobs that limit their time to adopt practices. Indeed, 52.1% of our sample indicated they received more than 80% of their income from an off-farm source. Another potential explanation for this negative relationship perhaps involves explanation of another predictor variable: producer visits with Extension.

The number of times a producer visits with Extension in a year (Q25_RCD) was significantly and positively associated with the adoption of several BMPs. Having at least one visit with Extension per year significantly increased the probability of adopting control access by 26.5%, field/salt/mineral locations by 20.1%, filter strips by 12.0%, heavy use area protection by 13.3%, pesticide management by 26.1%, soil testing/nutrient management by 38.8%, and stream crossing by 12.1%. In fact, interactions with Extension produced the largest probabilities of adoption (i.e., marginal effects) out of all 30 explanatory variables included in the models. This indicates that Extension and the information and services it provides are very effective in influencing adoption rates among beef cattle producers. Rahelizatovo (2002) found similar results in her study of Louisiana dairy producers as did Nyaupane and Gillespie (2009) in their study of Louisiana crawfish producers. Even more telling is the fact that 60% of survey respondents reported having zero visits with Extension in a typical year. This emphasizes just how significant even one visit per year with Extension can be in helping promote the adoption of conservation practices to protect water quality.

The significant influence of Extension visits on adoption may help explain the negative influence of college education on adoption. This inverse relationship suggests that education in the form of informal meetings, seminars, and workshops offered by groups like Extension may be more important in influencing adoption rates than education in the form of a formal 4-year or advanced college degree. Furthermore the area of study of respondents who indicated they had a college bachelor's or advanced degree is unknown. A non-agricultural related degree, for example, would be expected to be negatively associated with the adoption of agricultural-related conservation practices.

Another interesting finding pertains to the number of visits a producer had with NRCS in a year (Q26_RCD). Having at least one visit with NRCS per year significantly decreased the probability of adopting control access by 14.6%, critical area planting by 22%, field borders by 13.6%, and in-stream watering points by17.5%. In fact, this variable decreased the probability of adoption (although not significant in all cases) for every single BMP included in this study. On the surface, this result is unexpected given one of the primary roles of the NRCS is to promote conservation practice adoption among landowners and livestock producers. Consequently, one might expect having at least one visit with NRCS per year would increase the probability of adopting a majority of BMPs. Indeed, Kim et al. (2005) found positive associations between adoption and at least one visit with NRCS.

Discussion of these findings is not meant as a criticism toward the NRCS. In fact, these findings first and foremost speak to a significant opportunity for the NRCS, Extension, and other agencies and organizations in Texas to forge a strategic partnership aimed at increasing awareness and adoption of practices among the agricultural and livestock sectors. This idea will be further discussed in the next chapter. Our study findings, however, potentially speak to some underlying themes discovered through unsolicited phone calls, emails, and hand-written letters received from project participants suggesting an overwhelming mistrust of the government (especially the federal government) and a strong propensity to protect private property rights. In a study of private property owners in Texas and Utah, Jackson-Smith et al. (2005) found respondents strongly agreed their individual property rights were being threatened by governmental agencies implementing public policies to protect both environmental quality and human health on private lands. The NRCS is a government agency that often plays this contentious role on private lands in Texas. Furthermore, respondents strongly agreed that land ownership obligated them to be good stewards of the environment suggesting personal responsibility, rather than public or government responsibility, is preferred in the protection of natural resources on private lands. In our study of Texas beef cattle producers, respondents also demonstrated this similar attitude with over 94% of respondents agreeing with the statement, “It is my personal responsibility to help protect water quality.” One comment from a letter received from a participant sums up the complicated interplay between property rights and stewardship responsibility, “It seems the government wants the individual landowner to be responsible for the public’s water, but the public doesn’t have any responsibility back to the landowner.”

In addition to protecting private property rights, a mistrust of government agencies was a general theme uncovered from the unsolicited letters and phone calls from study participants. Comments including, “My neighbors do not feel the government is a credible source for help”, “The government does not care and I don’t need their help”, “If I fill out this survey, will the government come on my land and penalize me?” and “Sorry big brother, but your questions are too deep” speak to this point.

The negative relationship between visits with NRCS and adoption of water quality BMPs can also potentially be explained by a general dissatisfaction among participants with NRCS services. Sanders (2005) found consistent complaints among landowners with regard to how the NRCS handled requests for installation of specific BMPs. “Many landowners were disgruntled that they had requested tank or pond construction, and field personnel had refused to assist with the construction because they claimed that the chosen area would not work well” (Sanders 2005, 22). Furthermore, she found participants were dissatisfied with the amount of paperwork, hassle, and strings involved with conservation program participation and that these costs significantly outweighed program benefits. Texas beef cattle producers felt similar – the greatest barrier to participation in a government-funded cost-share program was the substantial requirements (red tape) of the government program itself. The NIFA-CEAP study previously discussed also found unfavorable attitudes toward NRCS among project participants (Osmond et al. 2012). Key informant interviews revealed some participants felt NRCS practices were over-engineered or over-priced, NRCS plans were broader than farmers wanted or were willing to adopt, and direct on-site relationships between farmers and NRCS conservation planners had suffered due to budget cuts resulting in conservation planning “by laptop” (Osmond et al. 2012).

Finally, it is worth noting that beef cattle producers have traditionally participated in fewer USDA conservation programs as compared to crop producers. Consequently, it is logical to observe a negative relationship between adoption and interactions with the USDA-NRCS. Furthermore, this study included a variety of practices applicable to rangeland, pasture, and cropland. As a result, the observed negative relationship might simply be explained by the fact that not all practices are applicable to our sample.

Having at least one other family member working on the farm (Q23_RCD) positively influenced the probability of adopting critical area planting by 13.2%, filter strips by 9.2%, and shade structures by 17.3%. These findings are in agreement with previous research findings, which suggest that extra labor on the farm is positively correlated with adoption.

The number of years spent running the livestock operation (Q21) only marginally increased the probability of adopting fencing and prescribed grazing by less than 1% each. This result is not all that surprising given previous research findings being split on the influence farming experience has on adoption behavior. Also worth noting is the fact that the number of years producers planned to run their operations in the future did not significantly influence adoption of any of the 18 BMPs included in the study. This finding could potentially speak to the changing trend of Texas agricultural lands being transferred to younger generations not reliant on agricultural production for income. Consequently, even if a producer indicated they continued to run their operation for 100 more years, the use of the operation may or may not stay in agriculture.

Annual income (Q29) was positively associated with the adoption of several BMPs. A higher salary increased the probability of adopting diversions by 8%, fencing by 4.5%, field borders by 6.8%, grassed waterways by 6.7%, heavy use area protection by 8.1%, stream bank/shoreline protection by 6.1%, and watering facilities by 4.3%. Several of these BMPs are capital-intensive BMPs, substantiating the positive relationship between salary and adoption. It is interesting to note, however, that while significant, a higher salary only increased the probability of BMP adoption by a small percentage across all BMPs.

Similar to annual income, the percentage of income coming from the beef cattle operation itself was positively associated with the adoption of several BMPs. A higher percentage of income from the operation significantly increased adoption of diversions by 15.3%, field/salt/mineral locations by 11.6%, fencing by 10.2%, grassed waterways by 10%, pesticide management by 15.1%, prescribed grazing by 10.2%, and shade structures by 9.4%. Previous research suggests a strong correlation between income from the operation and adoption of BMPs that maintain the long-term health of the operation (Kim et al. 2005). Collectively, these BMPs would be expected to promote long-term benefits for the operation in terms of forage health and production as well as erosion control.

The percentage of income coming from an off-farm source (Q31) was positively associated with the adoption of several BMPs. A higher percentage of income from an off-farm source significantly, but marginally, increased the probability of adopting diversions by 9.9%, heavy use area protection by 5.5%, in-stream watering points by 6.4%, mortality management by 5.8%, and watering facilities by 3.5%. Previous research suggests a greater percentage of off-farm income is associated with the adoption of capital-intensive practices rather than labor-intensive practices (Gedikoglu and McCann 2007).

Finally, membership in a Texas livestock organization (Q34) significantly increased the probability of adopting fencing by 13.6%, but decreased the probability of adopting filter strips by 9.5%, grassed waterways by 18.7%, heavy use area protection by 11.7%, shade structures by 14.2%, and stream bank/shoreline protection by 10.4%. This result was unexpected given a major goal of livestock organizations such as the Texas and Southwestern Cattle Raisers Association is to provide education to livestock producers about best management practices. Rahelizatovo (2002) found a similar result with membership in the Louisiana Dairy Herd Improvement Association (DHIA) negatively influencing adoption of several conservation practices. She attributed the result to potential conflicting goals between the DHIA and conservation practices themselves; DHIA seeks to maximize producer profit through increased productivity while some conservation practices favor overall environmental improvement over profit maximization. In our study of Texas beef cattle producers, one potential explanation may stem from the fact that 76% of respondents indicated they did not belong to a Texas livestock association. Furthermore, practices with negative associations might not necessarily be applicable to producers managing range/pasture operations. Consequently, the negative impacts of organization membership may be somewhat misleading.

4.6.2.3. Environmental Awareness Variable*s*

The environmental awareness construct consisted of 6 variables measuring overall knowledge of water quality issues and producer perception of water quality ratings in their area. The first variable (Q4) related to knowledge of the term “best management practice." Of the five knowledge questions included in the study, the BMP question had the greatest influence on adoption. Knowing the term "best management practice" significantly increased the probability of adopting control access by 18.6%, fencing by 18.8%, prescribed grazing by 13.0%, and soil testing by 17.5%.

The second knowledge question (Q5) addressed the term "nonpoint source pollution." Knowing what this term meant significantly influenced the probability of adopting filter strips by 16% and watering facilities by 14%.

Having the knowledge of bacteria being the major cause of water quality impairment in Texas (Q6) only increased the probability of adopting stream crossings by 8.2%.

Knowledge of efforts to control nonpoint source pollution through the Clean Water Act (Q7) did not significantly increase the probability of adopting any of the 18 items included in the study.

Finally, knowledge of the availability of financial assistance programs to help control nonpoint source pollution (Q8) significantly increased the probability of adopting field/salt/mineral locations by 15% and stream crossings by 19.3%. This result is interesting given alternative field/salt/mineral locations is not a cost-shared practice.

Collectively, knowledge of water quality issues appeared to have a fairly substantial influence on the adoption of water quality BMPs significantly contributing to the adoption of 8 out of the 16 BMPs included in the study. It could be argued that increased knowledge should influence adoption of all BMPs included in this study. One potential factor preventing this is the number of respondents reporting very low knowledge levels for each of the 5 knowledge questions. Only 50% of respondents were aware of the term “best management practice,” which was the highest rated knowledge question. Approximately 23% of respondents knew the term “nonpoint source pollution,” 37% were aware bacteria was the major cause of water quality impairment in the state, 31% were aware of efforts to control nonpoint source pollution through the Clean Water Act, and only 15% were aware of the availability of financial assistance programs to implement BMPs. Even despite the seemingly low knowledge level among respondents, knowledge still positively contributed to the adoption of half of the BMPs suggesting the important role that knowledge and information can play in influencing adoption behavior.

The final environmental awareness variable addressed the perception respondents have to water quality in their area (Q36_RCD). A perception of water quality being rated good or very good (as compared to fair or poor) significantly decreased the probability of adopting shade structures by 17.5% and watering facilities by 10.3%. This variable was only significant for 2 practices, but perhaps speaks to the point that individuals are less likely to be proactive about something they don’t see as a problem in the first place. Or, if they see it as a problem, they may not necessarily see it as their problem to fix as is the case with many common good resources (Hardin 1994). Mean water quality rating among all respondents was 3.28 (scale ranged from 1 to 5 with 1 being very poor and 5 being very good). A closer look at frequencies for each Likert category revealed that respondents were divided – roughly 50% perceived water quality to be rated good or very good while roughly 50% perceived water quality to be rated fair or worse.

4.6.2.4. Farm Characteristic Variables

Operator gender (Q15) significantly influenced adoption of several practices. Being a female operator significantly reduced the probability of adopting critical area planting by 16.5%, field borders by 25.3%, grassed waterways by 22.4%, heavy use area protection by 19.7%, in-stream watering points by 13.1%, and shade structures by 15.1%. In addition to the number of yearly visits with Extension, gender seemed to be a fairly significant factor affecting adoption behavior. It is worth noting that only 13% of respondents were female, substantiating the overwhelming significant influence of this variable. Furthermore, 84.3% of females in our sample were older than 50 and 30.1% were older than 70. This finding is similar to what other research has found on gender differences in conservation practice adoption especially related to labor-intensive practices (Bayard et al. 2006). This finding directly supports new initiatives spearheaded by nonprofit groups such as American Farmland Trust to help empower female landowners to become conservation leaders. According to the 2007 Census of Agriculture, nearly 30% of all farms in the United States are operated by women, an 11% increase since 2002. The American Farmland Trust (2013) labels women operators as the “largest underserved group in agriculture.” As a result, the American Farmland Trust, the Women, Food, and Agriculture Network (WFAN), and others are partnering to provide women-only learning opportunities designed to promote awareness of conservation issues and increased adoption of conservation practices. Initiatives likes these will undoubtedly become more critical as the number of female operators increase across the nation.

The total acreage included in the operation (Q19), did not significantly increase the probability of adopting any of the 18 items included in the study. In fact, this variable influenced predicted probabilities the least out of all the variables included in the study. In addition, the ratio of land owned to total land operated (OWN_PER) and the ratio of land rented to total land operated (RENT_PER) did not significantly increase the probability of adopting any of the 18 items included in the study. The lack of significance for these two variables is not surprising given the relationship between land tenure and adoption rates is complex and not fully understood (Weinkauf 2008).

Debt-asset ratio (Q32_RC) positively influenced the probability of adopting diversions by 7.9% and in-stream watering points by 5.4%. A higher debt-asset ratio is indicative of two different things (Rahelizatovo 2002): First, it can indicate a recent investment in adoption technology, which would increase the probability of adoption. Conversely, it can indicate investment in something other than adoption technology (i.e., college education, mortgage, car, medical bills, etc.), which would decrease the probability of conservation practice adoption. Both diversions and in-stream watering points are fairly capital-intensive practices suggesting the positive relationship between debt-asset ratio and adoption to mean a higher investment in conservation practice technology as suggested by Feder et al. (1985).

Having a stream running through the property (Q35_RCD) significantly increased the probability of adopting an in-stream watering point by 19.6%, but significantly decreased the probability of adopting pesticide management by 15.1%, shade structures by 13.8%, and watering facilities by 14.2%. The decreased probability associated with the adoption of pesticide management can potentially be explained by the risks associated with applying pesticides near surface water and the impacts of mechanical, biological, and cultural pest suppression techniques on water quality, erosion, and natural resources. The decreased probability associated with the adoption of shade structures can potentially be explained by the fact cattle are using shade provided by the stream's riparian area, negating the adoption of a separate shade structure. Finally, the decreased probability associated with the adoption of watering facilities suggests cattle are drinking water directly from the stream running through the property.

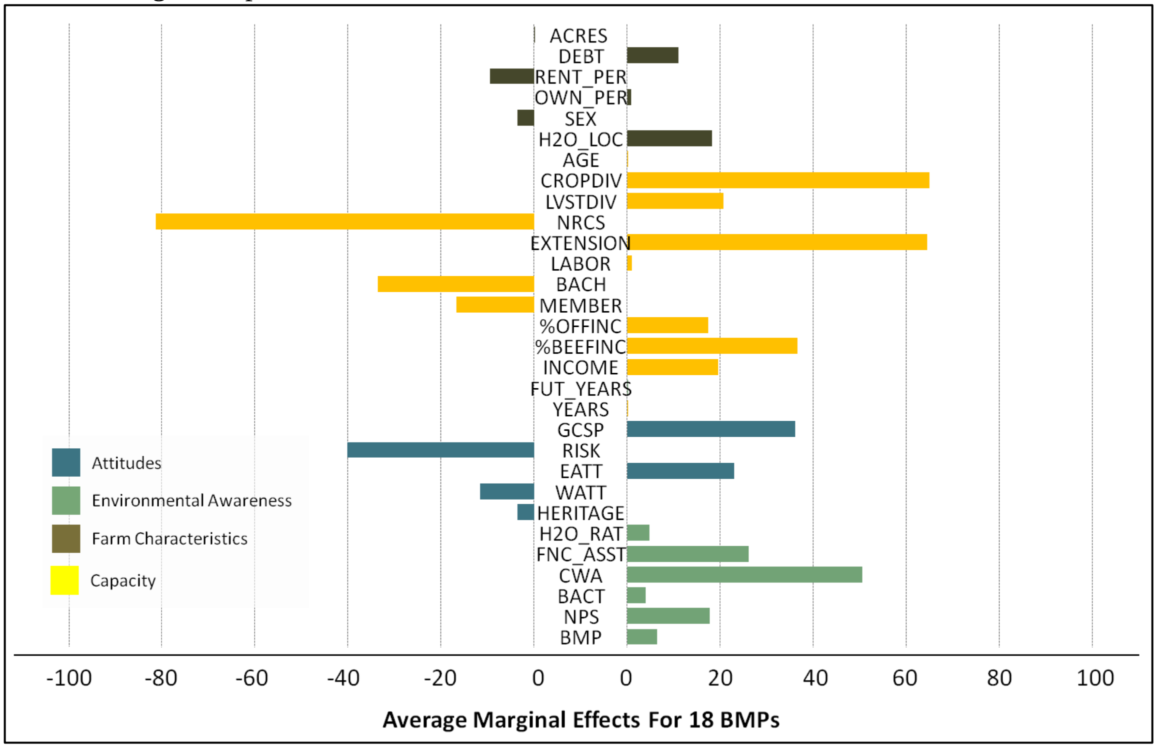
A general summary of the influence of each predictor variable on the adoption behavior of respondents is provided in Table 4.18. Graphical representation of the average magnitude and direction of marginal effects is provided in Figure 4.2.

Table 4.18
Summary of the direction of influence of predictor variables on the overall adoption of water quality best management practices by Texas beef cattle producers.

Variable	Description	Adoption Influence
Attitude		
EATT	Summated score on NEP scale	/
WATT	Summate score on water quality attitude scale	/
Q12	Prior participation in government cost-share program	+
Q24_RCD	Dummy for whether any family plans to take over farm	-
Q33_RCD	Dummy for risk-averse operator	+-
Capacity		
AGE	Age of operator	+
Q1_RC	Dummy for livestock diversity	+
Q2_RC	Dummy for crop diversity	+
Q17_RCD	Dummy for holding a college bachelor’s degree	-
Q23_RCD	Dummy for family members working on farm	+
Q21	Number of years running livestock operation	/
Q22	Number of years planning to run operation into future	/
Q29	Annual income (1-5 scale treated as continuous)	+
Q30	% operation income (1-5 scale treated as continuous)	+
Q31	% off-farm income (1-5 scale treated as continuous)	+
Q25_RCD	Dummy for visits with Extension	+
Q26_RCD	Dummy for visits with NRCS	-
Q34	Member of Texas livestock organization	-
Environmental Awareness		
Q4	Knowledge of term best management practice	+
Q5	Knowledge of term nonpoint source pollution (NPS)	+
Q6	Knowledge of bacteria as major cause of impairment	+
Q7	Knowledge of Clean Water Act to control NPS	/
Q8	Knowledge of financial assistance programs for NPS	+
Q36_RCD	Dummy for rating of water quality in area	-
Farm Characteristics		
Q15	Male/female	-
Q19	Total acreage in operation	/
OWN_PER	Ratio of land owned to total land operated	/
RENT_PER	Ratio of land rented to total land operated	/
Q32_RC	Dummy for debt-asset ratio	/
Q35_RCD	Dummy for nearest water body to operation	/

Notes. / denotes marginal influence; - denotes negative influence; + denotes positive influence.

Figure 4.2
Average direction and magnitude of marginal effects of predictor variables on overall adoption of best management practices.



CHAPTER V

SUMMARY AND CONCLUSIONS

5.1. Summary

Despite vast improvements in water quality since passage of the Clean Water Act, the United States continues to struggle with water pollution, particularly pollution originating from nonpoint sources across the landscape. In Texas alone, nearly half of all water bodies are considered impaired and do not meet their designated uses as outlined in the Texas Surface Water Quality Standards. Approximately 85% of these impairments are the result of both agricultural and urban nonpoint sources. With population in the state expected to double by 2040, significant investments by state natural resources agencies will be vital to not only ensure water quantity is sufficient, but also water quality for human use and consumption is sufficient as well.

The agricultural community has traditionally been viewed as good stewards of the environment. However, the sector has also frequently been blamed for being a major contributor to the state's current water quality problems. A number of research studies have tried to better pinpoint sources of water pollution through bacterial source tracking and other methodologies. While results of these studies definitively show that wildlife, feral hogs, failing septic systems, and other sources are potential contributors of pollution to surface water, the livestock sector is not without fault.

The agricultural industry in Texas is expansive and substantial, both from an economic and cultural standpoint. The beef cattle industry alone is worth nearly $15 billion to the Texas economy on an annual basis. Texas also ranks first in the nation in total inventory of cattle and calves. The management of agricultural nonpoint source pollution is complex. Like other states, Texas has shied away from direct regulation of nonpoint source pollution given the inherent difficulty involved in indentifying specific sources and contributors across the landscape. Furthermore, nonpoint source pollution does not mirror well-defined political and jurisdictional boundaries. Rather, state natural resources agencies have utilized a watershed approach to encourage the voluntary adoption of BMPs by landowners and livestock producers. Specific policy tools used to encourage voluntary adoption include educational programming and technical and financial assistance. Prior research has shown the efficacy of best management practices in removing contaminants from runoff. However, despite the water quality benefits and the available policy tools to encourage adoption, some producers choose not to adopt practices.

This study investigated factors influencing the adoption of 18 BMPs known to reduce levels of bacteria, sediment, and other contaminants in runoff originating from livestock operations. Specific study objectives included reviewing and summarizing current water quality protection efforts in Texas, reviewing the literature on technology adoption and barriers to adoption of BMPs in the agricultural sector, developing and administering a statistically valid, statewide survey of beef cattle producers to understand current adoption behavior and to quantitatively assess the extent to which variables related to capacity, environmental awareness, attitude, and farm characteristics influence producer adoption of water quality BMPs, and developing recommendations for policy makers and conservation program managers that increase adoption of and sustained management of water quality BMPs.

Current water quality protection efforts in Texas are implemented through diverse partnerships at the state, regional, and local scales and are guided by state policies set forth by federal law. Total maximum daily loads and watershed protection plans are mechanisms used to address water quality impairments identified through the Texas Integrated Report of Surface Water Quality. Once initiated, these projects seek the involvement of multiple stakeholders to address all potential sources of pollution and to devise a plan to minimize this pollution so the water body can resume meeting water quality standards. A significant portion of these plans includes strategies to encourage the voluntary adoption of BMPs among both urban and rural stakeholders residing within the impaired watershed. Various educational, technical, and financial assistance opportunities are utilized to implement the plan, encourage adoption, and improve water quality and the long-term health of the watershed. Significant project partners often include the TCEQ, TSSWCB, NRCS, EPA, Texas A&M AgriLife Extension, Texas A&M AgriLife Research, river authorities, and local nonprofit groups.

The literature on technology adoption in the agricultural sector is vast. However, very little literature exists concerning technology adoption in Texas, and even less exists concerning technology adoption among livestock producers. Because of the extensive literature, Prokopy’s (2008) meta-analysis of 55 adoption studies served as the foundation for this study in which she examined how factors related to capacity, attitudes, environmental awareness, and farm characteristics influence adoption.

Consequently, the literature explored for this study related to these constructs. Generally speaking, the literature is somewhat mixed on how several of these factors can either motivate or prevent adoption. However, factors related to increased knowledge, favorable environmental attitudes, and increased education all generally seem to promote adoption while factors related to increased operator age, decreased farm labor, and increased debt-asset ratio all generally seem to inhibit adoption.

To better understand the adoption behavior of Texas beef cattle producers and the influence of capacity, attitudes, environmental awareness, and farm characteristics on this behavior, a statewide survey of beef cattle producers was conducted between August and November 2013. The instrument was carefully designed, developed, and administered according to Dillman's *Tailored Design Method* (2000). A four-stage mailing protocol as well as a mixed-mode research approach were utilized to help maximize response rates. A stratified random sample of 1,700 producers was drawn by the Southern Plains Regional Field Office of the National Agricultural Statistics Service from beef cattle producers completing the 2012 Census of Agriculture. This sampling methodology ensured equal representation among all sizes of operations across the entire state. A total of 779 completed surveys were returned for an effective response rate of 48%.

Survey respondents were mostly male producers between 50-69 years old with some college/technical school education or a college bachelor's degree. Average operation size was 1,865 acres with the majority of respondents reporting they only raised beef cattle. A large number of respondents were not aware of the terms "best management practice” or “nonpoint source pollution.” Respondents were also not aware that elevated levels of bacteria were the major cause of water quality impairment or that financial assistance was available for the implementation of BMPs. Respondents reported other farmers and ranchers as being their primary source of information related to conservation programs and also reported they preferred to receive information through publications rather than through television, radio, newspaper, email, or social media.

Water quality and environmental attitudes were measured using two different scales. The water attitude scale was developed by the researcher and consisted of 12 items. Results showed an average summated score on these items to be 3.54, suggesting a fairly neutral attitude regarding water quality. Environmental attitude was measured using the NEP scale developed by Dunlap et al. in 1978 and revised in 2000. The scale consisted of 15 items. Results showed an average summated score on these items to be 3.19, suggesting an even more neutral attitude among respondents regarding the environment.

Adoption behavior was assessed by measuring Yes/No responses for each of the 18 practices included in the study. Approximately 90% of respondents adopted at least one water quality BMP. The most widely adopted practice was watering facilities; the least adopted practice was filter strips. The 18 BMPs belonged to three broad categories: erosion and sediment control; grazing management; and mortality, nutrient, and pesticide management. The most widely adopted category of BMPs was grazing management, followed by mortality, nutrient, and pesticide management, and erosion and sediment control. Among non-adopters of BMPs, major barriers related to lack of information, weather concerns, the practice costing too much out-of-pocket, not being able to see a field demonstration of the practice, and the practice not being applicable to the farm.

For each adopted practice, respondents were asked to rank their level of agreement with whether they had maintained the practice for at least 5 years following implementation. All adopters answered very favorably to this question suggesting producers had maintained the practices they implemented for several years.

Barriers to the participation in government cost-share programs were also assessed. Among non-participants, the greatest barrier was the excessive requirements (red tape) required of the government program followed by worrying about possible interference from the government, too much time being required to work through the application process, the practice standard not allowing enough flexibility in practice design, having difficulty understanding program requirements, and inadequate funding for the practice.

Univariate probit analysis was used to examine how factors related to capacity, attitudes, environmental awareness, and farm characteristics influence producer decisions to adopt water quality BMPs. Thirty variables relating to these 4 constructs were hypothesized to influence adoption behavior. Multicollinearity diagnostics revealed none of the variables were strongly correlated resulting in all 30 variables being included in each of the 18 probit analyses. Marginal effects of each predictor variable were assessed to determine the direct influence of each on the probability of the dependent variable equaling 1 (i.e., adoption). In addition, goodness of fit measures including

McFadden's R^2 and percent correctly predicted statistics were examined for each estimated model.

Results from the probit models suggest the number of visits with Extension to be the most significant factor influencing the probability of adopting BMPs. Interestingly, the number of visits with NRCS was the most significant factor reducing the probability of adopting several BMPs. This finding potentially suggests several different things. First, practices included in this study might not have been applicable to all producers and producers working with the NRCS may be more aware of which practices were not applicable to their operation, which might have negatively impacted their adoption of these non-applicable practices. Secondly, producers may be generally dissatisfied with how the NRCS conducts business, a finding echoed in several other research studies. Third, this finding could speak to a strong underlying private property rights orientation among beef cattle producers, a finding also echoed in another study that found private property owners preferred taking responsibility to manage their own land rather than having a government entity tell them how to manage the land. Finally, this finding could suggest an underlying general mistrust of government entities, a finding echoed in several unsolicited emails, phone calls, and hand-written letters received from participants.

The overwhelming positive influence of Extension suggests the potential impact this agency can have in influencing behavior change and adoption behavior among not only beef cattle producers, but all types of landowners in the state. Surprisingly, this strong positive relationship was found even despite the fact that 60% of respondents reported never visiting with Extension in a typical year. As Extension positions itself in the coming decades to address critical natural resources issues in the state, it will be imperative for administrators to initiate significant agency-wide marketing efforts so the citizens of Texas have a better understanding of what the agency is and what it does with regard to natural resource protection and education. As evidenced by this study, very few key constituents have frequent interactions with Extension and even fewer (15%) rely on Extension as their primary source of information related to conservation programs.

Furthermore, these findings are evidence that the NRCS could benefit from a strategic and purposeful long-term partnership with Extension to promote the sustained adoption and management of conservation practices through true collaborative efforts. This innovative partnership would combine the technical and financial assistance opportunities provided by the NRCS with the educational expertise of Extension professionals to identify land areas in most need of protection, educate land managers/owners in these areas on practices and their environmental benefits, and secure participation of these individuals in effective and sustained implementation of well designed management practices and systems.

Results from the probit analyses also revealed formal education levels appear to reduce the probability of adopting BMPs. This result generally goes against other research findings, which suggest increased educational levels translate to increased adoption of conservation practices. As previously discussed, this could be the result of producers with professional degrees holding off-farm jobs or it could suggest that informal education received through Extension programs and workshops are more important in influencing adoption behavior than formal education received through a 4-year college degree.

Operator gender appeared to significantly influence adoption rates of BMPs with females being less likely to adopt several practices, particularly vegetated practices requiring planting such as cover crops, filter strips, and grassed waterways. Nearly a third of our sample was comprised of women older than 70. This finding is similar to what other research has found and potentially supports the utilization of women-only educational opportunities to secure adoption from this important population group. The American Farmland Trust and other organizations are experimenting with these opportunities through women-only learning circles designed to empower women to become leaders in conservation agriculture.

Other significant predictors of adoption included prior participation in a government-funded cost-share program, annual income, percent income from the operation, and crop diversity. Participants who had previously participated in a government cost-share program were more likely to adopt several BMPs as compared to respondents never having participated in a cost-share program before. Annual income was positively associated with the probability of adopting BMPs, particular those practices that were highly capital-intensive. Finally, the percentage of income derived from the operation positively influenced adoption behavior. Those with a higher portion of their income originating from the operation were more likely to adopt several practices, particularly those that helped ensure forage health and production as well as erosion control. Participants indicating they grew two or more types of crops were much more likely to adopt several practices, particularly vegetated practices requiring planting of seeds as well as pesticide and nutrient management BMPs.

Producer environmental and water quality attitudes only marginally influenced adoption. This finding is perhaps somewhat misleading given respondents had fairly neutral attitudes as measured on both attitude scales. A greater effect might have been observed had producer attitudes measured more negative or more positive.

The consistent negative association between membership in a Texas livestock organization and BMP adoption was not as expected. Rahelizatovo (2002) found a similar result in her study of Louisiana dairy producers. One potential explanation for this stems from the fact that very few respondents actually belonged to a livestock organization, which could have produced this negative association. Furthermore, practices with negative associations simply might not have been applicable to producers managing range/pasture operations.

Total land acreage as well as land tenure did not significantly influence adoption of BMPs. Furthermore, the proximity of the closest water body to the operation, operator experience, and the number of years planning on running the operation only marginally influenced adoption behavior among respondents. These findings could speak to the growing trend in Texas of agricultural land changing hands to younger operators who do not intend to rely on agriculture production for income.

In summary, the most significant predictors of adoption among survey respondents included visits with Extension, prior participation in a government cost-share program, crop diversity, annual income, and percent income from the operation.

The most significant variables reducing the probability of adoption among survey respondents included education, gender, visits with NRCS, membership in a livestock organization, and having a family member take over the operation.

5.2. Theoretical Implications

This study utilized facets of the diffusion of innovations theory, theory of reasoned action, and theory of planned behavior as its theoretical framework and to guide selection of independent variables for the probit models. While 30 different explanatory variables comprising four different constructs were examined, results from this study overwhelmingly suggest that adoption decisions are incredibly complex and dynamic.

Examination of the adoption behavior of Texas beef cattle producers revealed practices that were highly observable on the landscape, compatible with the existing operation, provided a relative advantage to the producer, and simplistic in their implementation were more highly adopted as compared to practices not possessing these qualities. The importance of trialability was investigated by including lack of field demonstrations as a potential barrier to adoption. Among non-adopters, this ranked as the third highest barrier. Furthermore, the important role of social systems and communication channels in encouraging the diffusion of technologies was evidenced by the fact that 43% of producers indicated other farmers and ranchers as their primary source of conservation information and 65% of respondents preferred to receive information in publication format. This study was not able to investigate how time influenced the adoption decision and consequently was not able to separate respondents into innovators, early adopters, early majority, late majority, or laggards. Future research involving this population would benefit from better understanding this element of the adoption process.

The theory of reasoned action and planned behavior incorporate attitudes, subjective norms, and perceived behavioral control into the adoption model. This study investigated participant attitudes toward the environment and water quality and found respondents held very neutral attitudes toward both. Consequently, attitudes were not found to significantly influence the adoption decision. Future research would benefit from understanding whether spatial differences in attitudes exist across the state and how measures of attitudes can predict environmentally-friendly behavior. In addition, this study investigated the role of subjective norms by asking participants to indicate whether a practice not being respected by a neighbor inhibited adoption of the practice. Respondents were neutral on this particular item suggesting subjective norms are potentially not as important in the adoption decision as are other factors. Finally, perceived behavioral control was investigated through statements aimed at understanding an individual's perceived ease or difficulty in adopting the practices included in the study (i.e., did not feel I had enough skill, did not feel I had enough information). Indeed, an individual's perception of not having enough information and skill to implement a practice ranked high as barriers to implementation suggesting perceived behavioral control to be important in the adoption decision.

Results from this study suggest components from all three models of adoption are relevant in understanding the adoption behavior of Texas beef cattle producers. As other studies have indicated, these models are not perfect nor do they capture every aspect of the adoption decision. However, they certainly provide a valuable framework to guide adoption studies and to enable a better and enhanced understanding of adoption behavior with regard to conservation practices.

5.3. Conclusions and Recommendations

This study showed the adoption of BMPs by Texas beef cattle producers is influenced by variables related to capacity, attitudes, environmental awareness, and farm characteristics. It also revealed several barriers related to adoption of practices and participation in government-funded cost-share programs like EQIP, WHIP, etc. Results of the analyses emphasize:

- 90% of beef cattle producers are adopting at least one water quality BMP.
- Beef cattle producers are maintaining practices after implementation.
- Very few beef cattle producers are aware of common terms including "best management practice" and "nonpoint source pollution." Furthermore, they are not aware that elevated levels of bacteria are the major cause of water quality impairment in Texas or that financial assistance programs exist to aid in BMP implementation.
- The primary source of information related to conservation practices are other farmers and ranchers.
- Beef cattle producers prefer to receive information about conservation practices from publications (i.e., factsheets, manuals) rather than newspaper, internet, television, radio, or social media.

- Among non-adopters of practices, the major barriers appear to be related to lack of information, weather concerns, the practice costing too much out-of-pocket, not being able to see a field demonstration of the practice prior to implementation, and the practice not being applicable to the operation.
- Among non-participants in government-funded cost-share programs, the major barriers appear to be related to excessive requirements (red tape) of the program, worrying about possible interference from the government in management of the operation, the application process being too time consuming, and inflexible practice standards.
- The most significant predictors of adoption among survey respondents include visits with Extension, prior participation in a government cost-share program, crop diversity, annual income, and percent income from the operation.
- The most significant factors reducing the probability of adoption among survey respondents include education, gender, visits with NRCS, membership in a livestock organization, and having a family member take over the operation.

Based on results of the analyses, several recommendations are provided:

- Extension appears to play a significant role in encouraging adoption of BMPs among beef cattle producers. However, 60% of respondents never visit with Extension in a typical year and only 15% of respondents rely on Extension as their primary source of information related to conservation programs.
    - *Recommendation*: Extension administrators should initiate a substantial marketing campaign in the coming years to place the agency at the forefront of

critical natural resource issues facing the state of Texas. These efforts would help raise awareness among citizens about the agency and effectively position the agency to be a leader in educational programming that increases knowledge and promotes behavior change. Some efforts are currently underway within Extension including the new Water Initiative and Water Education Network that both seek to revitalize water-related educational programming as well as research and extension collaborations.

- Visits with the NRCS appear to be consistently negatively associated with the probability of adopting BMPs among beef cattle producers.
    - *Recommendation*: The NRCS and Extension should forge a strategic and deliberate long-term partnership that draws on the expertise of each agency to promote the sustained adoption and management of BMPs to protect water quality. Leaders from the Southern Extension and Research Activities Information Exchange Group (SERA-IEG-6) recognize this need as well and have begun exploring opportunities to initiate such a partnership.
- Female operators appear to be significantly less likely to adopt several BMPs suggesting the potential presence of substantial gender roles within the Texas beef cattle industry.
    - *Recommendation:* Extension, in concert with the NRCS and other interested partners, should consider regularly hosting women-only learning opportunities modeled after the Women Caring for the Land^{SM} program initiated by the Women, Food and Agriculture Network and the American Farmland Trust. This

program employs women-only meetings and utilizes a learning circle format to help women build confidence and support for one another to take action in the implementation of conservation programs on their land.

- Beef cattle producers overwhelmingly preferred printed publications (factsheets, newsletters, manuals) over any other format of information including social media, websites, newspaper, radio, and television.
  - *Recommendation:* To aid in information dissemination among this population, Extension and other parties involved in conservation programs should encourage development of short factsheets and publications that are easy to read and understand. This type of information could prove useful in helping landowners understand a specific practice, its benefits, and how it can be implemented.
- Among non-adopters, the most significant *controllable* barriers to BMP adoption were not having enough information, the practice costing too much out-of-pocket, and not being able to see a field demonstration of the practice prior to implementation.
  - *Recommendation*: Not having enough information can be addressed through recommendations already provided, but especially through educational programming offered by Extension and other non-governmental groups including non-profit organizations. Extension already conducts educational programming aimed at encouraging adoption of conservation programs, but these efforts need to be continued and perhaps even intensified. Again, a strategic partnership with the NRCS could aid in this effort. The high costs of practice implementation can

be offset through economic incentives provided by agencies like the NRCS and FSA. However, if producers are burdened by the application process or do not understand the program requirements, the perceived economic costs of implementation may be too hard to overcome. Indeed, nearly 80% of respondents did not even know financial assistance was available for BMP implementation. Consequently, through education, the NRCS should strive to make its financial assistance programs more widely known. Finally, field demonstrations of specific and highly effective practices should be encouraged especially in critical areas known to contribute substantial contaminants to surface water. Previous research has also found the use of field demonstrations to be highly effective at encouraging adoption.

- Among non-participants, the most significant *controllable* barriers to participation in a government-funded cost-share program were the excessive requirements of the program, feeling worried about possible interference from the government, the application process being too time consuming, and inflexible practice standards.
    - *Recommendation*: A 2006 report by the United States Government Accountability Office documented stakeholder views on participation in six USDA conservation programs. Stakeholders consistently identified these same barriers and recommended increasing funding, improving education and outreach, streamlining paperwork requirements, and allowing more flexibility in program participation and eligibility requirements as mechanisms to encourage greater participation in USDA conservation programs (GAO 2006). In recent

years, the NRCS has attempted to streamline its application process, yet application burdens remain a significant barrier among beef cattle producers as do worries about government interference and inflexible practice standards. Consequently, the recommendations listed above should continue to be examined by the NRCS.

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APPENDIX A

OUTCOME LETTER FROM THE TEXAS A&M UNIVERSITY INSTITUTIONAL REVIEW BOARD, HUMAN SUBJECTS PROTECTION PROGRAM

DIVISION OF RESEARCH

Office of Research Compliance and Biosafety

TEXAS A&M UNIVERSITY

APPROVAL DATE: 04/29/2013

MEMORANDUM

TO:	Jennifer Peterson ALRSRCH - Agrilife Research - Soil & Crop Sciences
FROM:	Institutional Review Board
SUBJECT:	Amendment Approval

Protocol Number:	IRB2012-0263
Title:	Barriers to the Adoption of Water Quality Best Management Practices by Texas Livestock Producers
Review Type:	Expedite
Approval Period:	05/15/2012 **To** 03/30/2014
Review Categories and Regulatory Determinations:	Category 7: Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies
Documents Reviewed and Approved:	

Description of Submission:	Recruitment materials and the survey instrument have been finalized. A $1 token incentive will be sent to participants receiving a paper questionnaire during the first survey packet mailing.
Comments:	Materials have been finalized and the investigator is requesting implementation. The survey appears adequate and does not contain sensitive matters. Recruitment scripts and letters have been generated and appear appropriate. There does not appear to be any elevation of risk.

This research project has been approved. As principal investigator, you assume the following responsibilities

750 Agronomy Road, Suite 2701
1186 TAMU
College Station, TX 77843-1186

Tel. 979.458.1467 Fax. 979.862.3176
http://rcb.tamu.edu

APPENDIX B

PAPER VERSION OF SURVEY INSTRUMENT

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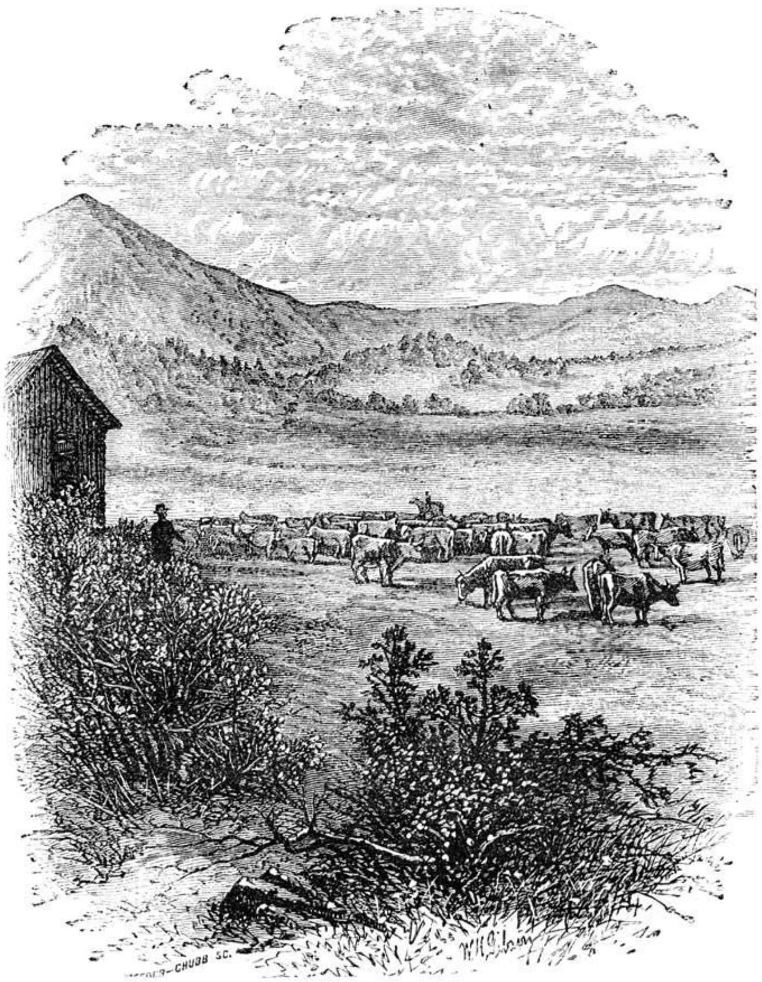
Implementation of Best Management Practices to Protect Water Resources



Texas A&M AgriLife Extension

TAMU IRB#2012-0236 Approved: 04/02/2013 Expiration Date: 03/30/2014

TSSWCB

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Throughout this survey, you will be asked questions about your livestock operation and best management practices. Please read all of the questions in their entirety so you do not miss any special instructions. Please mark the answer(s) that best reflect your situation. Please note the marking instructions below. All information will be kept strictly confidential and will not be shared. Thank you for your participation and your time!

MARKING INSTRUCTIONS
CORRECT: ● INCORRECT: ⊘ ⊠ ⊖ ⊙

Please use a black or blue ink pen, or a dark pencil.

1. At the current time, do you raise any of the following type(s) of livestock on your property? *(Mark all that apply)*

O Beef Cattle	O Horses
O Dairy Cattle	O Goats
O Poultry	O Sheep
O Swine	O Other: ______________________

2. Please mark any other crops you raise for sale and/or feeding *(Mark all that apply)*

O Corn	O Sorghum	O Cotton	O Soybeans
O Fruit	O Timber	O Hay	O Vegetables
O Oats	O Wheat	O Rice	O Other: ______________________

3. Please tell us your opinion on each of the following statements.

Statement	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
a) It is my personal responsibility to help protect water quality.	O	O	O	O	O
b) The government should pay farmers to implement practices that help protect water quality.	O	O	O	O	O
c) Laws intended to protect water quality are badly needed.	O	O	O	O	O
d) It is the responsibility of the government to help protect water quality.	O	O	O	O	O
e) The government should not be involved at all in agriculture.	O	O	O	O	O
f) Laws intended to protect water quality are unnecessary.	O	O	O	O	O
g) The way I care for my property can impact water quality in lakes, rivers, and streams.	O	O	O	O	O
h) Improperly managed agricultural land can have negative consequences for water quality.	O	O	O	O	O
i) What I do on my property doesn't have much impact on overall water quality.	O	O	O	O	O
j) Improperly managed agricultural land has minimal consequences for overall water quality.	O	O	O	O	O
k) Implementation of conservation practices can be profitable.	O	O	O	O	O
l) Taking action on my property to improve water quality is too expensive for me.	O	O	O	O	O

Please continue to the next page.

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MARKING INSTRUCTIONS
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4. **Are you aware of the term best management practice (BMP)?** ***(Mark one)***
   - O Yes
   - O No

5. **Are you aware of the term nonpoint source pollution (NPS)?** ***(Mark one)***
   - O Yes
   - O No

6. **Are you aware the major cause of impairment in Texas water bodies is due to elevated levels of bacteria?** ***(Mark one)***
   - O Yes
   - O No

7. **Are you aware of the efforts to control nonpoint sources of water pollution through the Clean Water Act?** ***(Mark one)***
   - O Yes
   - O No

8. **Are you aware financial assistance is available from agencies and organizations to help implement best management practices to control nonpoint sources of pollution?** ***(Mark one)***
   - O Yes
   - O No

9. **The following are <u>standard statements</u> used previously by researchers that deal with the <u>relationship between humans and the environment</u>. For each statement, please indicate the <u>extent to which you agree or disagree</u>.**

Statement	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
a) We are approaching the limit of the number of people the earth can support.	O	O	O	O	O
b) Humans have the right to modify the natural environment to suit their needs.	O	O	O	O	O
c) When humans interfere with nature it often produces disastrous consequences.	O	O	O	O	O
d) Human ingenuity will insure that we do NOT make the earth unlivable.	O	O	O	O	O
e) Humans are severely abusing the environment.	O	O	O	O	O
f) The earth has plenty of natural resources if we just learn how to develop them.	O	O	O	O	O
g) Plants and animals have as much right as humans to exist.	O	O	O	O	O
h) The balance of nature is strong enough to cope with the impacts of modern industrial nations.	O	O	O	O	O
i) Despite our special abilities, humans are still subject to the laws of nature.	O	O	O	O	O
j) The so-called "ecological crisis" facing humankind has been greatly exaggerated.	O	O	O	O	O
k) The earth is like a spaceship with very limited room and resources.	O	O	O	O	O
l) Humans were meant to rule over the rest of nature.	O	O	O	O	O
m) The balance of nature is very delicate and easily upset.	O	O	O	O	O
n) Humans will eventually learn enough about how nature works to be able to control it.	O	O	O	O	O
o) If things continue on their present course, we will soon experience a major ecological catastrophe.	O	O	O	O	O

Please continue to the next page.

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MARKING INSTRUCTIONS

CORRECT: ● INCORRECT: ⊘ ⊗ ◒ ◓

10. Below is a list of best management practicies used on beef cattle operations to protect water quality (remove bacteria, sediment, nutrients, and other pollutants from runoff). Please indicate which practices, if any, you have implemented on your livestock operation in the last 5 years by marking either Yes, or No.

THEN, for the practices you marked "Yes" for, please indicate the extent to which you agree or disagree that you have maintained the best management practice following implementation.

I have INSTALLED the following BMPs on land I either own, rent, or lease in the last 5 years.				*If YES, following implementation, to what extent do you agree you have MAINTAINED the following BMPs.*				
Best Management Practice	**No**	**Yes**	**If Yes . . .**	**Strongly Disagree**	**Disagree**	**Neither Agree nor Disagree**	**Agree**	**Strongly Agree**
a) Control access of animals and machinery to sensitive areas	O	O	⇨	O	O	O	O	O
b) Critical area planting	O	O	⇨	O	O	O	O	O
c) Diversion	O	O	⇨	O	O	O	O	O
d) Feed, salt, and/or mineral locations	O	O	⇨	O	O	O	O	O
e) Fencing	O	O	⇨	O	O	O	O	O
f) Field border	O	O	⇨	O	O	O	O	O
g) Filter strip	O	O	⇨	O	O	O	O	O
h) Grassed waterway	O	O	⇨	O	O	O	O	O
i) Heavy use area protection	O	O	⇨	O	O	O	O	O
j) In-stream watering points	O	O	⇨	O	O	O	O	O
k) Mortality management	O	O	⇨	O	O	O	O	O
l) Pesticide management	O	O	⇨	O	O	O	O	O
m) Prescribed grazing	O	O	⇨	O	O	O	O	O
n) Shade structures	O	O	⇨	O	O	O	O	O
o) Soil testing & nutrient management	O	O	⇨	O	O	O	O	O
p) Streambank and shoreline protection	O	O	⇨	O	O	O	O	O
q) Stream crossing	O	O	⇨	O	O	O	O	O
r) Watering facility (trough, tank, pond)	O	O	⇨	O	O	O	O	O

Please continue to the next page.

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MARKING INSTRUCTIONS

CORRECT: ● INCORRECT: ⊘ ⊗ ◒ ◓

11. The following statements indicate potential barriers that might have prevented you from implementing a certain best management practice. Please indicate the extent to which you agree or disagree with each statement being a barrier for you.

Barrier Statement	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
a) I do not own the land I use for my livestock operation.	O	O	O	O	O
b) I did not think the practice would be profitable.	O	O	O	O	O
c) I did not want to deal with the additional management and labor required to implement or maintain the practice.	O	O	O	O	O
d) I did not have enough information about the practice.	O	O	O	O	O
e) I was uncertain the practice would help improve water quality.	O	O	O	O	O
f) The practice cost too much out-of-pocket to implement.	O	O	O	O	O
g) I did not feel I had enough skill to implement the practice.	O	O	O	O	O
h) The market conditions were unfavorable at the time.	O	O	O	O	O
i) The practices are not well-respected by other farmers/ranchers.	O	O	O	O	O
j) The practices are not applicable to my farm/ranch situation.	O	O	O	O	O
k) Weather factors (i.e., drought, temperature) were uncertain at the time.	O	O	O	O	O
l) I did not have confidence in the people or agencies providing information on conservation practices.	O	O	O	O	O
m) I was not able to see a field demonstration of the practice beforehand.	O	O	O	O	O

12. Have you ever participated in a government funded cost-share program? (Examples: Conservation Reserve Program, Water Quality Management Plan, Wetland Reserve Program, EQIP - Environmental Quality Incentives Program)? *(Mark one)*

O No

O Yes, I have participated in ______________________________

Please continue to the next page.

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MARKING INSTRUCTIONS
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13. The following statements indicate potential barriers that might have prevented you from participating in a government funded conservation or cost-share program. Please indicate the extent to which you agree or disagree with each statement being a barrier for you.

Barrier Statement	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
a) The amount of funding provided by the program was inadequate.	O	O	O	O	O
b) The government practice standard did not allow enough flexibility in practice design and implementation.	O	O	O	O	O
c) There were too many requirements (red tape) of the government program.	O	O	O	O	O
d) There was too much time required to work through the application process.	O	O	O	O	O
e) I was worried about possible interference with my flexibility to change land use practices in the future.	O	O	O	O	O
f) I had difficulty understanding the program requirements.	O	O	O	O	O

14. The following is a list of actions governments or other entities could consider in order to promote conservation practices. Please indicate the extent to which you agree or disagree with each specific action.

Actions	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
a) Education programs.	O	O	O	O	O
b) One-on-one, onsite technical assistance.	O	O	O	O	O
c) Increased financial assistance and incentives.	O	O	O	O	O
d) Government control over land if pollution originating from land is deemed to be excessive.	O	O	O	O	O
e) Penalties (fines) if pollution from land is not controlled.	O	O	O	O	O
f) Make eligibility for other agricultural subsidies dependent on use of conservation practices.	O	O	O	O	O
g) Tax deductions for using conservation practices.	O	O	O	O	O
h) Target funding to assist landowners with the most severe pollution problems.	O	O	O	O	O
i) Increased public recognition of environmental achievements of livestock producers.	O	O	O	O	O

Please continue to the next page.

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MARKING INSTRUCTIONS
CORRECT: ● INCORRECT: ⊘ ⊗ ◒ ◓

15. Are you male or female? *(Mark one)*

O Male O Female

16. In what year were you born? 19 ☐☐

17. What is the highest level of education you have completed? *(Mark one)*

O Less than high school

O High school graduate or GED

O Some college or technical school (Associates degree)

O College Bachelor's degree

O Advanced degree (Master's, Ph.D., D.V.M., M.D. etc.)

18. In what zip code is your farm located? If your farm spans more than one zip code, please indicate the primary zip code.

5-digit Zip Code ☐☐☐☐☐

19. How many acres of land are included in your entire farm operation?

☐☐☐☐☐☐ Acres

20. Of the land used for your livestock operation, how many acres do you own and/or rent?

☐☐☐☐☐☐ Acres owned

☐☐☐☐☐☐ Acres leased or rented

21. How many years have you been running your livestock operation? ☐☐☐ Years

22. How many years do you intend to continue running your livestock operation? ☐☐☐ Years

23. How many family members besides yourself work on the livestock operation at least once per week? *(Mark one)*

O 0 O 1 O 2 O 3 or more

24. Do any of your children or any other family members plan to take over your livestock operation upon your retirement? *(Mark one)*

O Yes O No O Unsure

25. In a typical year, how many times do you have business contact with the Texas A&M AgriLife Extension Service? Please include attending seminars or workshops, and in-person, telephone, and email contact. *(Mark one)*

O None O 1 - 3 times O 4 times or more

26. In a typical year, how many times do you have business contact with the Natural Resources Conservation Service (NRCS)? Please include attending seminars or workshops, and in-person, telephone, and email contact. *(Mark one)*

O None O 1 - 3 times O 4 times or more

27. Who is your primary source of information related to conservation practices? *(Mark one)*

O Environmental advocacy groups (i.e., Sierra Club)

O Farm/ranch Businesses

O Farm/ranch Organizations

O Non-Extension Media

O Natural Resources Conservation Service (NRCS)

O Other farmers/ranchers

O Soil and Water Conservation District (SWCD)

O Texas A&M AgriLife Extension Service

⇨ *Over*

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MARKING INSTRUCTIONS
CORRECT: ● INCORRECT: ⊘ ⊗ ◒ ◓

28. **In what format do you prefer to receive information related to conservation practices?** ***(Mark one)***

- O Publications (factsheet, brochures, manuals, etc)
- O Social Media (Facebook, Twitter, etc.)
- O Newspaper O Email O Internet
- O Television O Radio

29. **Which of the following best describes your annual income?** ***(Mark one)***

- O less than $30,000
- O $30,000 to $59,999
- O $60,000 to $89,999
- O $90,000 to $119,999
- O More than $120,000

30. **Approximately what percentage of your 2012 household net income came from your beef cattle operation?** ***(Mark one)***

- O 0 percent
- O 1 to 20 percent
- O 21 to 40 percent
- O 41 to 60 percent
- O 61 to 80 percent
- O 81 to 100 percent

31. **Approximately what percentage of your 2012 household net income came from an off-farm source?** ***(Mark one)***

- O 0 percent
- O 1 to 20 percent
- O 21 to 40 percent
- O 41 to 60 percent
- O 61 to 80 percent
- O 81 to 100 percent

32. **What is your farm's approximate debt to asset ratio?** ***(Mark one)***

- O 0:1 (no debt)
- O 0.1-1:1 (debt less than or equal to your assets)
- O 1.1-2:1 (debt a little more than equal to double the amount of your assets)
- O 2.1-3:1 (debt a little more than double to triple the amount of your assets)
- O 3.1-4.1 (debt a little more than triple to quadruple the amount of your assets)

33. **Relative to other investors, how would you characterize yourself?** ***(Mark one)***

- O I tend to take on substantial levels of risk in my investment decisions.
- O I neither seek nor avoid risk in my investment decisions.
- O I tend to avoid risk when possible in my investment decisions.

34. **Are you a member of a Texas livestock organization (Examples: Texas and Southwestern Cattle Raisers Association, Texas Cattle Feeders Association)?** ***(Mark one)***

- O Yes O No

35. **How close is the nearest water body (creek, stream, river, lake) to your livestock operation?** ***(Mark one)***

- O A water body (creek, steam, river) runs through my livestock operation.
- O Less than 1 mile
- O More than 1 mile

36. **In general, how would you rate the quality of water bodies (creeks, streams, rivers, lakes) in your area?** ***(Mark one)***

- O Very poor O Poor O Fair O Good O Very good

Thank you for taking the time to complete this survey!

APPENDIX C

WELCOME POSTCARD

In the next few days, we will be mailing you a survey about your livestock operation and best management practices to help protect water quality. We are telling you about this now so you will not be surprised we are asking these questions.

To help save on copying and mailing costs, you can go online now and complete the short survey here:

http://tx.ag/BMPsurvey

YOUR 4-DIGIT CODE IS: **<<UniqueID>>**

If you have any questions, please contact me by phone at 979-862-8072 or by email at jlpeterson@ag.tamu.edu. Thank you in advance for your participation.

Sincerely,

Jennifer Peterson
Texas A&M AgriLife Extension Service

TAMU IRB#2012-0236 Approved: 04/02/2013 Expiration Date: 03/30/2014

APPENDIX D

COVER LETTER MAILED IN SURVEY PACKET #1

DEPARTMENT OF SOIL & CROP SCIENCES

TEXAS A&M AGRILIFE EXTENSION

Dear Texas Livestock Producer,

TAMU IRB#2012-0236 Approved: 04/02/2013 Expiration Date: 03/30/2014

About one week ago, you received a postcard requesting your participation in a survey about best management practices to protect water quality. As you are aware, the quality of water in our state's creeks, streams, rivers, and lakes is very important. The agricultural sector is often singled out as having a major impact on water quality. This has resulted in increased pressure for beef cattle producers to adopt best management practices intended to reduce bacteria, sediment, and nutrient pollution. What remains unknown is the extent to which producers are voluntarily adopting these management practices and the barriers producers might face in choosing whether to adopt a particular practice.

To help answer these questions, the Texas A&M AgriLife Extension Service and the Texas State Soil and Water Conservation Board have developed a brief survey. As a beef cattle producer in Texas, you belong to a very knowledgeable group of people who can help answer these questions. The success of this study depends on your input. *Please complete the survey within 5 days of receiving this letter.*

All individual responses will be kept *strictly confidential*. The questionnaire has an identification number for mailing purposes only. Your name will never be placed on the questionnaire or associated with your responses.

We request the primary decision maker on the farm or ranch complete the survey. If you would rather complete the survey online, please visit:

http://tx.ag/BMPsurvey

YOUR 4-DIGIT CODE IS: **«UniqueID»**

I am a graduate student in the Department of Soil and Crop Sciences at Texas A&M University. I cannot complete my study without your valued participation. I would be happy to answer any questions you might have. My telephone number is 979-862-8072 and my email address is jlpeterson@ag.tamu.edu.

Thank you in advance for your participation,

Sincerely,

Jennifer Peterson
Texas A&M AgriLife Extension Service

Heep Center
Texas A&M AgriLife Extension Service
370 Olsen Boulevard | TAMU MS 2474 | College Station, Texas 77843-2474

Tel. 979.845.2425 | Fax. 979.845.0604 | AgriLifeExtension.tamu.edu

APPENDIX E

REMINDER POSTCARD

Last week, a survey seeking information about your livestock operation was mailed to you. *If you have already completed and returned the survey, please accept our sincerest thanks.* If not, we would appreciate you returning it as soon as possible. It is important your response be included in the study so the results accurately represent Texas beef cattle producers.

If you would rather complete the survey online, please visit:

http://tx.ag/BMPsurvey

YOUR 4-DIGIT CODE IS: **<<UniqueID>>**

If you have any questions, please contact me by phone at 979-862-8072 or by email at jlpeterson@ag.tamu.edu. Thank you in advance for your participation.

Sincerely,

Jennifer Peterson
Texas A&M AgriLife Extension Service

TAMU IRB#2012-0236 Approved: 04/02/2013 Expiration Date: 03/30/2014

APPENDIX F

COVER LETTER MAILED IN SURVEY PACKET #2

DEPARTMENT OF SOIL & CROP SCIENCES

TEXAS A&M AGRILIFE EXTENSION

Dear Texas Livestock Producer,

TAMU IRB#2012-0236 Approved: 04/02/2013 Expiration Date: 03/30/2014

About three weeks ago, I wrote to you requesting your participation in a survey on the use of best management practices by Texas beef cattle producers. As of today, I have not received your completed survey. *If you have already responded to the survey and we have not yet received your response, please accept my sincerest thanks.*

I am writing again because of the importance of each survey to the usefulness of this study. The accuracy of the study results depends on the participation of producers such as you.

The information gathered in this survey will be used to understand the extent to which producers are voluntarily adopting best management practices, and what barriers producers might face in choosing whether to adopt a particular practice. *Please complete the survey within 5 days of receiving this letter.*

All individual responses will be kept *strictly confidential*. The questionnaire has an identification number for mailing purposes only. Your name will never be placed on the questionnaire or associated with your responses.

The questionnaire should be completed by the person with primary decision-making authority on the farm. In the event your survey has been misplaced, a replacement is enclosed. If you would rather complete the survey online, please visit:

http://tx.ag/BMPsurvey

YOUR 4-DIGIT CODE IS: **«UniqueID»**

I am a graduate student in the Department of Soil and Crop Sciences at Texas A&M University. I cannot complete my study without your valued participation. I would be happy to answer any questions you might have. My telephone number is 979-862-8072 and my email address is jlpeterson@ag.tamu.edu.

Thank you in advance for your participation,

Sincerely,

Jennifer Peterson
Texas A&M AgriLife Extension Service

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Tel. 979.845.2425 | Fax. 979.845.0604 | AgriLifeExtension.tamu.edu

APPENDIX G

SPSS AND LIMDEP ANALYSIS SYNTAX

```
*****Peterson Data Syntax - Created 12-17-2013*****

****Recode NEP Scale even number items - Question 9 (B, D, F, H, J, L, N)*****

RECODE Q9B Q9D Q9F Q9H Q9J Q9L Q9N (1=5) (2=4) (3=3) (4=2) (5=1) INTO Q9B_RC Q9D_RC Q9F_RC
Q9H_RC
   Q9J_RC Q9L_RC Q9N_RC.
VARIABLE LABELS  Q9B_RC 'RECODE 9b. Standard Statement - Humans have the right to modify the '+
   'natural environment to suit their needs.' /Q9D_RC 'RECODE 9d. Standard Statement - Human '+
   'ingenuity will insure that we do NOT make the earth unlivable.' /Q9F_RC 'RECODE 9f. Standard '+
   'Statement - The earth has plenty of natural resources if we just learn how to develop them.'
   /Q9H_RC 'RECODE 9h. Standard Statement - The balance of nature is strong enough to cope with the '+
   'impacts of modern industrial nat' /Q9J_RC "RECODE 9j. Standard Statement - The so-called "+
   "'ecological crisis' facing humankind has been greatly exaggerated." /Q9L_RC 'RECODE 9l. '+
   'Standard Statement - Humans were meant to rule over the rest of nature.' /Q9N_RC 'RECODE 9n. '+
   'Standard Statement - Humans will eventually learn enough about how nature works to be able to '+
   'control it.'.
EXECUTE.

******Recode Importance of Protecting Water Quality items******

RECODE Q3E Q3F (1=5) (2=4) (3=3) (4=2) (5=1) INTO Q3E_RC Q3F_RC.
VARIABLE LABELS  Q3E_RC 'RECODE 3e. Your Opinion - The government should not be involved at all '+
   'in agriculture' /Q3F_RC 'RECODE 3f. Your Opinion - Laws intended to protect water quality are '+
   'unnecessary'.
EXECUTE.


******Recode Ag's Potential to Affect Water Quality items******

RECODE Q3I Q3J (1=5) (2=4) (3=3) (4=2) (5=1) INTO Q3I_RC Q3J_RC.
VARIABLE LABELS  Q3I_RC "RECODE 3i. Your Opinion - What I do on my property doesn't have much "+
   "impact on overall water quality" /Q3J_RC 'RECODE 3j. Your Opinion - Improperly managed '+
   'agricultural land has minimal consequences for overall water quality'.
EXECUTE.

RECODE Q3L (1=5) (2=4) (3=3) (4=2) (5=1) INTO Q3L_RC.
VARIABLE LABELS  Q3L_RC 'RECODE 3l. Your Opinion - Taking action on my property to improve water '+
   'quality is too expensive for me'.
EXECUTE.

*********RECODE Q32 to Q32_RC (Debt - Asset Ratio)******

RECODE Q32 (1=0) (2=1) (3=2) (4=3) (5=4) INTO Q32_RC.
FORMATS Q32_RC (F8.0).
VARIABLE LABELS  Q32_RC "Debt to Asset Ratio".
```

```
VALUE LABELS Q32_RC 0 '0:1 (no debt)' 1 '0.1-1:1 (debt less than or equal to your assets)' 2 '1.1-2:1 (debt a little more than equal to double the amoount of your assets)'
3 '2.1-3:1 (debt a little more than double to triple the amount of your assets)' 4 '3.1-4:1 (debt a little more than triple to quadruple the amount of your assets)'.
VARIABLE LEVEL /Q32_RC (ORDINAL).
EXECUTE.

*****Reliability Estimate - All Question 3 - WITH K and L *****

RELIABILITY
  /VARIABLES=Q3A Q3B Q3C Q3D Q3E_RC Q3F_RC Q3G Q3H Q3I_RC Q3J_RC Q3K Q3L_RC
  /SCALE('Water Quality Attitude') ALL
  /MODEL=ALPHA
  /SUMMARY=TOTAL.


***** Reliability Estimate - NEP Scale*****

RELIABILITY
  /VARIABLES=Q9A Q9B_RC Q9C Q9D_RC Q9E Q9F_RC Q9G Q9H_RC Q9I Q9J_RC Q9K Q9L_RC Q9M
Q9N_RC Q9O
  /SCALE('NEP Scale') ALL
  /MODEL=ALPHA
  /SUMMARY=TOTAL.


*****************These are not included in the analysis. They were simply tests to estimate reliability of various scale composition************************


*****Reliability Estimate - Importance of Protecting Water Quality*****

RELIABILITY
  /VARIABLES=Q3A Q3B Q3C Q3D Q3E_RC Q3F_RC
  /SCALE('Importance of Protecting Water Quality') ALL
  /MODEL=ALPHA
  /SUMMARY=TOTAL.

*****Reliability Estimate - Ag's Potential to Affect Water Quality*****

RELIABILITY
  /VARIABLES=Q3G Q3H Q3I_RC Q3J_RC
  /SCALE("Ag's Potential to Affect Water Quality") ALL
  /MODEL=ALPHA
  /SUMMARY=TOTAL.

*****Reliability Estimate - All Question 3 - No K or L *****

RELIABILITY
  /VARIABLES=Q3A Q3B Q3C Q3D Q3E_RC Q3F_RC Q3G Q3H Q3I_RC Q3J_RC
  /SCALE('All Question 3 - No K or L') ALL
```

```
  /MODEL=ALPHA
  /SUMMARY=TOTAL.


*****Reliability Estimate - ONLY K and L *****

RELIABILITY
  /VARIABLES=Q3K Q3L_RC
  /SCALE('ONLY K and L') ALL
  /MODEL=ALPHA
  /SUMMARY=TOTAL.

************************************************************************************************************
*********************************************

*********Calculate WATT (Water Quality Attitude) Scale******************

COMPUTE WATT=MEAN(Q3A,Q3B,Q3C,Q3D,Q3E_RC,Q3F_RC,Q3G,Q3H,Q3I_RC,Q3J_RC,Q3K,Q3L_RC).
FORMATS WATT (F8.2).
VARIABLE LABELS  WATT "Water Quality Attitude".
VARIABLE LEVEL /WATT (SCALE).
EXECUTE.

***********Calculate EATT (NEP - Environmental Attitude) Scale******************

COMPUTE
EATT=MEAN(Q9A,Q9B_RC,Q9C,Q9D_RC,Q9E,Q9F_RC,Q9G,Q9H_RC,Q9I,Q9J_RC,Q9K,Q9L_RC,Q9M,Q9N_RC,Q
9O).
FORMATS EATT (F8.2).
VARIABLE LABELS  EATT "Environmental Attitude".
VARIABLE LEVEL /EATT (SCALE).
EXECUTE.



*********************COMPARE Datasets for appropriateness of aggregate
analyses************************************

*****Multivariate Test - WATT, EATT, and Form Type****************

GLM WATT EATT BY FORM_TYPE
  /METHOD=SSTYPE(3)
  /INTERCEPT=INCLUDE
  /PRINT=DESCRIPTIVE ETASQ OPOWER HOMOGENEITY
  /CRITERIA=ALPHA(.05)
  /DESIGN= FORM_TYPE.


******Chi Square Test BMP (Q10A_INS - Q10R_INS) x Form Type*******
```

******Chi Square tests were only included to demonstrate inadequate cell size for comparison******************

```
CROSSTABS
  /TABLES=FORM_TYPE BY Q10A_INS
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.

CROSSTABS
  /TABLES=FORM_TYPE BY Q10B_INS
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.

CROSSTABS
  /TABLES=FORM_TYPE BY Q10C_INS
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.

CROSSTABS
  /TABLES=FORM_TYPE BY Q10D_INS
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.

CROSSTABS
  /TABLES=FORM_TYPE BY Q10E_INS
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.

CROSSTABS
  /TABLES=FORM_TYPE BY Q10F_INS
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.

CROSSTABS
  /TABLES=FORM_TYPE BY Q10G_INS
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.
```

```
CROSSTABS
  /TABLES=FORM_TYPE BY Q10H_INS
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.

CROSSTABS
  /TABLES=FORM_TYPE BY Q10I_INS
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.

CROSSTABS
  /TABLES=FORM_TYPE BY Q10J_INS
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.


CROSSTABS
  /TABLES=FORM_TYPE BY Q10K_INS
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.

CROSSTABS
  /TABLES=FORM_TYPE BY Q10L_INS
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.

CROSSTABS
  /TABLES=FORM_TYPE BY Q10M_INS
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.

CROSSTABS
  /TABLES=FORM_TYPE BY Q10N_INS
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.
```

```
CROSSTABS
  /TABLES=FORM_TYPE BY Q10O_INS
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.

CROSSTABS
  /TABLES=FORM_TYPE BY Q10P_INS
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.

CROSSTABS
  /TABLES=FORM_TYPE BY Q10Q_INS
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.

CROSSTABS
  /TABLES=FORM_TYPE BY Q10R_INS
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.

********************************END Chi Square Tests****************************************************

USE ALL.

*********RECODE Dummy Variable Education to Bachelor's or Not******

RECODE Q17 (1 thru 3=0) (4 thru 5=1) INTO Q17_RCD.
FORMATS Q17_RCD (F8.0).
VARIABLE LABELS  Q17_RCD "Bachelor's Degree Dummy".
VALUE LABELS Q17_RCD 0 'Less than Bachelors Degree' 1 'Bachelors Degree or Greater'.
VARIABLE LEVEL /Q17_RCD (NOMINAL).
EXECUTE.


*********RECODE Dummy Variable Family Members working on Farm******

RECODE Q23 (0=0) (1 thru 3=1) INTO Q23_RCD.
FORMATS Q23_RCD (F8.0).
VARIABLE LABELS  Q23_RCD "Family Members working on Farm Dummy".
VALUE LABELS Q23_RCD 0 'Zero Family Members' 1 'One or more Family Members'.
VARIABLE LEVEL /Q23_RCD (NOMINAL).
EXECUTE.
```

```
*********RECODE Dummy Variable Visits with Extension in 2012********

RECODE Q25 (0=0) (1 thru 2=1) INTO Q25_RCD.
FORMATS Q25_RCD (F8.0).
VARIABLE LABELS  Q25_RCD "Visits with Extension in 2012 Dummy".
VALUE LABELS Q25_RCD 0 'Zero Visits with Extension in 2012' 1 'One or more Visits with Extension in 2012'.
VARIABLE LEVEL /Q25_RCD (NOMINAL).
EXECUTE.

*********RECODE Dummy Variable Visits with NRCS in 2012******

RECODE Q26 (0=0) (1 thru 2=1) INTO Q26_RCD.
FORMATS Q26_RCD (F8.0).
VARIABLE LABELS  Q26_RCD "Visits with NRCS in 2012 Dummy".
VALUE LABELS Q26_RCD 0 'Zero Visits with NRCS in 2012' 1 'One or more Visits with NRCS in 2012'.
VARIABLE LEVEL /Q26_RCD (NOMINAL).
EXECUTE.

*********RECODE Dummy Variable Risk Aversion******

RECODE Q33 (1 thru 2=0) (3=1) INTO Q33_RCD.
FORMATS Q33_RCD (F8.0).
VARIABLE LABELS  Q33_RCD "Risk Aversion Dummy".
VALUE LABELS Q33_RCD 0 'Risk Neutral' 1 'Risk Aversion'.
VARIABLE LEVEL /Q33_RCD (NOMINAL).
EXECUTE.

*********RECODE Dummy Variable Nearest Water Body********

RECODE Q35 (1=1) (2 thru 3=0) INTO Q35_RCD.
FORMATS Q35_RCD (F8.0).
VARIABLE LABELS  Q35_RCD "Nearest Water Body Dummy".
VALUE LABELS Q35_RCD 0 'No Stream Near Property' 1 'Stream Through Property'.
VARIABLE LEVEL /Q35_RCD (NOMINAL).
EXECUTE.


******RECODE Dummy Variable Debt: Asset Ratio Q32_RC to Q32_RCD********

RECODE Q32_RC (0=0) (2 thru 5=1) INTO Q32_RCD.
FORMATS Q32_RCD (F8.0).
VARIABLE LABELS Q32_RCD 'Debt:Asset Ratio Dummy'.
VALUE LABELS Q32_RCD 0 'No debt' 1 'Some debt'.
VARIABLE LEVEL /Q32_RCD (NOMINAL).
EXECUTE.

*********RECODE Dummy Variable Water Quality Rating********

RECODE Q36 (1 thru 3=0) (4 thru 5=1) INTO Q36_RCD.
FORMATS Q36_RCD (F8.0).
```

```
VARIABLE LABELS  Q36_RCD "Water Quality Rating".
VALUE LABELS Q36_RCD 0 'Fair or Less' 1 'Good or Better'.
VARIABLE LEVEL /Q36_RCD (NOMINAL).
EXECUTE.

*********RECODE Dummy Variable % Income From Operation********

RECODE Q30 (1=0) (2 thru 6=1) INTO Q30_RCD.
FORMATS Q30_RCD (F8.0).
VARIABLE LABELS  Q30_RCD "% Income From Operation Dummy".
VALUE LABELS Q30_RCD 0 'No income from operation' 1 '1-100% income from operation'.
VARIABLE LEVEL /Q30_RCD (NOMINAL).
EXECUTE.

*********RECODE Dummy Variable % Income From Off-Farm Source********

RECODE Q31 (1=0) (2 thru 6=1) INTO Q31_RCD.
FORMATS Q31_RCD (F8.0).
VARIABLE LABELS  Q31_RCD "% Income From Off-Farm Source Dummy".
VALUE LABELS Q31_RCD 0 'No income from off-farm source' 1 '1-100% income from off-farm source'.
VARIABLE LEVEL /Q31_RCD (NOMINAL).
EXECUTE.

*********RECODE Q24 Dummy Family Members Planning to Take Over Operation********

RECODE Q24 (0 thru 1=0) (2=1) INTO Q24_RCD.
FORMATS Q24_RCD (F8.0).
VARIABLE LABELS  Q24_RCD "Family members taking over farm".
VALUE LABELS Q24_RCD 0 'No or unsure' 1 'Yes'.
VARIABLE LEVEL /Q24_RCD (NOMINAL).
EXECUTE.

*********RECODE Q29 Dummy Income********

RECODE Q29 (1 thru 2=0) (3 thru 5=1) INTO Q29_RCD.
FORMATS Q29_RCD (F8.0).
VARIABLE LABELS  Q29_RCD "Annual income".
VALUE LABELS Q29_RCD 0 'Less than $60,000' 1 'More than $60,000'.
VARIABLE LEVEL /Q29_RCD (NOMINAL).
EXECUTE.

************************Diversity of Livestock**************************

COMPUTE Q1_RC=0.
IF SUM(BEEF,DAIRY,POULTRY,SWINE,HORSES,GOATS,SHEEP,OTHER)>=2 Q1_RC=1.
FORMATS Q1_RC (F8.0).
VARIABLE LABELS  Q1_RC "Diversity of Livestock".
VALUE LABELS Q1_RC 0 'One type of livestock' 1 'More than one type of livestock'.
VARIABLE LEVEL /Q1_RC (NOMINAL).
EXECUTE.
```

```
************************Diversity of Crop*************************

COMPUTE Q2_RC=0.
IF
SUM(Q2_CORN,Q2_FRUIT,Q2_OATS,Q2_SORG,Q2_TIMB,Q2_WHEAT,Q2_COT,Q2_HAY,Q2_RICE,Q2_SOY,Q2_V
EG,Q2_OTHER)>=2 Q2_RC=1.
FORMATS Q2_RC (F8.0).
VARIABLE LABELS  Q2_RC "Diversity of Crops".
VALUE LABELS Q2_RC 0 'One type of crop' 1 'More than one type of crop'.
VARIABLE LEVEL /Q2_RC (NOMINAL).
EXECUTE.

*****Adopter/Non-Adopter*********

COMPUTE ADOPTION=0.
IF
SUM(Q10A_INS,Q10B_INS,Q10C_INS,Q10D_INS,Q10E_INS,Q10F_INS,Q10G_INS,Q10H_INS,Q10I_INS,Q10J_IN
S,Q10K_INS,Q10L_INS,Q10M_INS,Q10N_INS,Q10O_INS,Q10P_INS,Q10Q_INS,Q10R_INS)>=1 ADOPTION=1.
FORMATS ADOPTION (F8.0).
VARIABLE LABELS  ADOPTION "Adopter/Non-Adopter".
VALUE LABELS ADOPTION 0 'Non-Adopter' 1 'Adopter'.
VARIABLE LEVEL /ADOPTION (NOMINAL).
EXECUTE.

*****Create New Age_Group Variable********

 IF (AGE <= 30) AGE_GROUP=1.
 IF (AGE > 30 AND AGE <= 49) AGE_GROUP=2.
 IF (AGE > 49 AND AGE <= 69) AGE_GROUP=3.
 IF (AGE > 69) AGE_GROUP=4.


*****Create New Acreage_Group Variable********

IF (Q19 <= 25) ACREAGE_GROUP=1.
IF (Q19 > 25 AND Q19 <= 100)  ACREAGE_GROUP=2.
IF (Q19 > 100 AND Q19 <= 250) ACREAGE_GROUP=3.
IF (Q19 > 250 AND Q19 <= 500) ACREAGE_GROUP=4.
IF (Q19 > 500 AND Q19 <= 1000) ACREAGE_GROUP=5.
IF (Q19 > 1000 AND Q19 <=2500) ACREAGE_GROUP=6.
IF (Q19 > 2500) ACREAGE_GROUP=7.


**********Percentage of Land Owned : Total Land Operated********************

COMPUTE OWN_PERCENT=0.
IF Q19>0 OWN_PERCENT=Q20A/Q19.
VARIABLE LABELS  OWN_PERCENT "Percentage of Land Owned : Total Land Operated".
VARIABLE LEVEL /OWN_PERCENT (SCALE).
EXECUTE.
```

**********Percentage of Land Rented : Total Land Operated*******************

```
COMPUTE RENT_PERCENT=0.
IF Q19>0 RENT_PERCENT=Q20B/Q19.
VARIABLE LABELS  RENT_PERCENT "Percentage of Land Rented : Total Land Operated".
VARIABLE LEVEL /RENT_PERCENT (SCALE).
EXECUTE.

**********COMPUTE Grand Mean BMP Maintenance Scale Q10A_MAI - Q10R_MAI*****************

COMPUTE BMP_MAI_GrandMean=MEAN(Q10A_MAI, Q10B_MAI, Q10C_MAI, Q10D_MAI, Q10E_MAI,
Q10F_MAI, Q10G_MAI,
Q10H_MAI, Q10I_MAI, Q10J_MAI, Q10K_MAI, Q10L_MAI, Q10M_MAI, Q10N_MAI, Q10O_MAI, Q10P_MAI,
Q10Q_MAI, Q10R_MAI).
VARIABLE LABELS  BMP_MAI_GrandMean "BMP Maintenance Scale Grand Mean".
VARIABLE LEVEL /BMP_MAI_GrandMean (SCALE).
EXECUTE.

**********COMPUTE Grand Mean BMP Barrier Scale Q11A - Q11M*****************

COMPUTE BMP_BAR_GrandMean=MEAN(Q11A, Q11B, Q11C, Q11D, Q11E, Q11F, Q11G, Q11H, Q11I, Q11J,
Q11K, Q11L, Q11M).
VARIABLE LABELS BMP_BAR_GrandMean "BMP Barriers Scale Grand Mean".
VARIABLE LEVEL /BMP_BAR_GrandMean (SCALE).
EXECUTE.

**********COMPUTE Grand Mean GCS Barrier Scale Q13A - Q13F*****************


COMPUTE GCS_BAR_GrandMean=MEAN(Q13A, Q13B, Q13C, Q13D, Q13E, Q13F).
VARIABLE LABELS GCS_BAR_GrandMean "GCS Barrier Scale Grand Mean".
VARIABLE LEVEL /GCS_BAR_GrandMean (SCALE).
EXECUTE.


******RESPONSE MODE DESCRIPTIVES****

******EVERYONE Who Reseponded********
********Descriptives for Form Type***********

USE ALL.
FREQUENCIES VARIABLES=FORM_TYPE
  /ORDER=ANALYSIS.

******Responses Filtered to Eliminate Duplicates**********
********Descriptives for Form Type***********

USE ALL.
COMPUTE filter_$=(DUPLICATE = 0).
VARIABLE LABELS filter_$ 'DUPLICATE = 0 (FILTER)'.
```

```
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMATS filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE.

FREQUENCIES VARIABLES=FORM_TYPE
  /ORDER=ANALYSIS.

******Responses Filtered to Eliminate Duplicates AND Non-Beef Producers**********
********Descriptives for Form Type***********

USE ALL.
COMPUTE filter_$=(DUPLICATE = 0 AND BEEF=1).
VARIABLE LABELS filter_$ 'DUPLICATE = 0 AND BEEF=1 (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMATS filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE.

FREQUENCIES VARIABLES=FORM_TYPE
  /ORDER=ANALYSIS.

******END RESPONSE MODE DESCRIPTIVES**********


*********************************************************************
*********************JEN START HERE***********************
*********************************************************************

*******************Before Descriptives and Inferential Analyses*******************************

USE ALL.
COMPUTE filter_$=(DUPLICATE = 0 AND BEEF=1).
VARIABLE LABELS filter_$ 'DUPLICATE = 0 AND BEEF=1 (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMATS filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE.

*******************************Begin Research Questions***************************************

********RQ1***************************

FREQUENCIES VARIABLES=Q10A_INS Q10B_INS Q10C_INS Q10D_INS Q10E_INS Q10F_INS Q10G_INS
Q10H_INS
    Q10I_INS Q10J_INS Q10K_INS Q10L_INS Q10M_INS Q10N_INS Q10O_INS Q10P_INS Q10Q_INS Q10R_INS
  /ORDER=ANALYSIS.


* Custom Tables.
CTABLES
```

```
  /VLABELS VARIABLES=Q10A_INS Q10B_INS Q10C_INS Q10D_INS Q10E_INS Q10F_INS Q10G_INS
Q10H_INS
    Q10I_INS Q10J_INS Q10K_INS Q10L_INS Q10M_INS Q10N_INS Q10O_INS Q10P_INS Q10Q_INS Q10R_INS
    DISPLAY=LABEL
  /TABLE Q10A_INS [C][COUNT F40.0, ROWPCT.COUNT PCT40.0] + Q10B_INS [C][COUNT F40.0,
ROWPCT.COUNT
    PCT40.0] + Q10C_INS [C][COUNT F40.0, ROWPCT.COUNT PCT40.0] + Q10D_INS [C][COUNT F40.0,
ROWPCT.COUNT
    PCT40.0] + Q10E_INS [C][COUNT F40.0, ROWPCT.COUNT PCT40.0] + Q10F_INS [C][COUNT F40.0,
ROWPCT.COUNT
    PCT40.0] + Q10G_INS [C][COUNT F40.0, ROWPCT.COUNT PCT40.0] + Q10H_INS [C][COUNT F40.0,
ROWPCT.COUNT
    PCT40.0] + Q10I_INS [C][COUNT F40.0, ROWPCT.COUNT PCT40.0] + Q10J_INS [C][COUNT F40.0,
ROWPCT.COUNT
    PCT40.0] + Q10K_INS [C][COUNT F40.0, ROWPCT.COUNT PCT40.0] + Q10L_INS [C][COUNT F40.0,
ROWPCT.COUNT
    PCT40.0] + Q10M_INS [C][COUNT F40.0, ROWPCT.COUNT PCT40.0] + Q10N_INS [C][COUNT F40.0,
ROWPCT.COUNT
    PCT40.0] + Q10O_INS [C][COUNT F40.0, ROWPCT.COUNT PCT40.0] + Q10P_INS [C][COUNT F40.0,
ROWPCT.COUNT
    PCT40.0] + Q10Q_INS [C][COUNT F40.0, ROWPCT.COUNT PCT40.0] + Q10R_INS [C][COUNT F40.0,
ROWPCT.COUNT
    PCT40.0]
  /CLABELS ROWLABELS=OPPOSITE
  /CATEGORIES VARIABLES=Q10A_INS [1, 0, OTHERNM] EMPTY=INCLUDE
  /CATEGORIES VARIABLES=Q10B_INS [1, 0, OTHERNM] EMPTY=INCLUDE
  /CATEGORIES VARIABLES=Q10C_INS [1, 0, OTHERNM] EMPTY=INCLUDE
  /CATEGORIES VARIABLES=Q10D_INS [1, 0, OTHERNM] EMPTY=INCLUDE
  /CATEGORIES VARIABLES=Q10E_INS [1, 0, OTHERNM] EMPTY=INCLUDE
  /CATEGORIES VARIABLES=Q10F_INS [1, 0, OTHERNM] EMPTY=INCLUDE
  /CATEGORIES VARIABLES=Q10G_INS [1, 0, OTHERNM] EMPTY=INCLUDE
  /CATEGORIES VARIABLES=Q10H_INS [1, 0, OTHERNM] EMPTY=INCLUDE
  /CATEGORIES VARIABLES=Q10I_INS [1, 0, OTHERNM] EMPTY=INCLUDE
  /CATEGORIES VARIABLES=Q10J_INS [1, 0, OTHERNM] EMPTY=INCLUDE
  /CATEGORIES VARIABLES=Q10K_INS [1, 0, OTHERNM] EMPTY=INCLUDE
  /CATEGORIES VARIABLES=Q10L_INS [1, 0, OTHERNM] EMPTY=INCLUDE
  /CATEGORIES VARIABLES=Q10M_INS [1, 0, OTHERNM] EMPTY=INCLUDE
  /CATEGORIES VARIABLES=Q10N_INS [1, 0, OTHERNM] EMPTY=INCLUDE
  /CATEGORIES VARIABLES=Q10O_INS [1, 0, OTHERNM] EMPTY=INCLUDE
  /CATEGORIES VARIABLES=Q10P_INS [1, 0, OTHERNM] EMPTY=INCLUDE
  /CATEGORIES VARIABLES=Q10Q_INS [1, 0, OTHERNM] EMPTY=INCLUDE
  /CATEGORIES VARIABLES=Q10R_INS [1, 0, OTHERNM] EMPTY=INCLUDE.

********RQ2**************************

****Item by Item*****

DESCRIPTIVES VARIABLES=Q10A_MAI Q10B_MAI Q10C_MAI Q10D_MAI Q10E_MAI Q10F_MAI Q10G_MAI
Q10H_MAI
    Q10I_MAI Q10J_MAI Q10K_MAI Q10L_MAI Q10M_MAI Q10N_MAI Q10O_MAI Q10P_MAI Q10Q_MAI
Q10R_MAI
```

```
  /STATISTICS=MEAN STDDEV MIN MAX SKEWNESS.

* Custom Tables.
CTABLES
  /VLABELS VARIABLES=Q10A_MAI Q10B_MAI Q10C_MAI Q10D_MAI Q10E_MAI Q10F_MAI Q10G_MAI
Q10H_MAI
    Q10I_MAI Q10J_MAI Q10K_MAI Q10L_MAI Q10M_MAI Q10N_MAI Q10O_MAI Q10P_MAI Q10Q_MAI
Q10R_MAI
    DISPLAY=LABEL
  /TABLE Q10A_MAI [COUNT F40.0, ROWPCT.VALIDN PCT40.0, TOTALS[COUNT F40.0, ROWPCT.VALIDN
PCT40.1,
    MEAN F40.2, STDDEV F40.2]] + Q10B_MAI [COUNT F40.0, ROWPCT.VALIDN PCT40.0, TOTALS[COUNT
F40.0,
    ROWPCT.VALIDN PCT40.1, MEAN F40.2, STDDEV F40.2]] + Q10C_MAI [COUNT F40.0, ROWPCT.VALIDN
PCT40.0,
    TOTALS[COUNT F40.0, ROWPCT.VALIDN PCT40.1, MEAN F40.2, STDDEV F40.2]] + Q10D_MAI [COUNT
F40.0,
    ROWPCT.VALIDN PCT40.0, TOTALS[COUNT F40.0, ROWPCT.VALIDN PCT40.1, MEAN F40.2, STDDEV
F40.2]] +
    Q10E_MAI [COUNT F40.0, ROWPCT.VALIDN PCT40.0, TOTALS[COUNT F40.0, ROWPCT.VALIDN PCT40.1,
MEAN
    F40.2, STDDEV F40.2]] + Q10F_MAI [COUNT F40.0, ROWPCT.VALIDN PCT40.0, TOTALS[COUNT F40.0,
    ROWPCT.VALIDN PCT40.1, MEAN F40.2, STDDEV F40.2]] + Q10G_MAI [COUNT F40.0, ROWPCT.VALIDN
PCT40.0,
    TOTALS[COUNT F40.0, ROWPCT.VALIDN PCT40.1, MEAN F40.2, STDDEV F40.2]] + Q10H_MAI [COUNT
F40.0,
    ROWPCT.VALIDN PCT40.0, TOTALS[COUNT F40.0, ROWPCT.VALIDN PCT40.1, MEAN F40.2, STDDEV
F40.2]] +
    Q10I_MAI [COUNT F40.0, ROWPCT.VALIDN PCT40.0, TOTALS[COUNT F40.0, ROWPCT.VALIDN PCT40.1,
MEAN
    F40.2, STDDEV F40.2]] + Q10J_MAI [COUNT F40.0, ROWPCT.VALIDN PCT40.0, TOTALS[COUNT F40.0,
    ROWPCT.VALIDN PCT40.1, MEAN F40.2, STDDEV F40.2]] + Q10K_MAI [COUNT F40.0, ROWPCT.VALIDN
PCT40.0,
    TOTALS[COUNT F40.0, ROWPCT.VALIDN PCT40.1, MEAN F40.2, STDDEV F40.2]] + Q10L_MAI [COUNT
F40.0,
    ROWPCT.VALIDN PCT40.0, TOTALS[COUNT F40.0, ROWPCT.VALIDN PCT40.1, MEAN F40.2, STDDEV
F40.2]] +
    Q10M_MAI [COUNT F40.0, ROWPCT.VALIDN PCT40.0, TOTALS[COUNT F40.0, ROWPCT.VALIDN PCT40.1,
MEAN
    F40.2, STDDEV F40.2]] + Q10N_MAI [COUNT F40.0, ROWPCT.VALIDN PCT40.0, TOTALS[COUNT F40.0,
    ROWPCT.VALIDN PCT40.1, MEAN F40.2, STDDEV F40.2]] + Q10O_MAI [COUNT F40.0, ROWPCT.VALIDN
PCT40.0,
    TOTALS[COUNT F40.0, ROWPCT.VALIDN PCT40.1, MEAN F40.2, STDDEV F40.2]] + Q10P_MAI [COUNT
F40.0,
    ROWPCT.VALIDN PCT40.0, TOTALS[COUNT F40.0, ROWPCT.VALIDN PCT40.1, MEAN F40.2, STDDEV
F40.2]] +
    Q10Q_MAI [COUNT F40.0, ROWPCT.VALIDN PCT40.0, TOTALS[COUNT F40.0, ROWPCT.VALIDN PCT40.1,
MEAN
    F40.2, STDDEV F40.2]] + Q10R_MAI [COUNT F40.0, ROWPCT.VALIDN PCT40.0, TOTALS[COUNT F40.0,
    ROWPCT.VALIDN PCT40.1, MEAN F40.2, STDDEV F40.2]]
  /CLABELS ROWLABELS=OPPOSITE
```

```
  /CATEGORIES VARIABLES=Q10A_MAI Q10B_MAI Q10C_MAI Q10D_MAI Q10E_MAI Q10F_MAI Q10G_MAI
Q10H_MAI
    Q10I_MAI Q10J_MAI Q10K_MAI Q10L_MAI Q10M_MAI Q10N_MAI Q10O_MAI Q10P_MAI Q10Q_MAI
Q10R_MAI ORDER=A
    KEY=VALUE EMPTY=INCLUDE TOTAL=YES POSITION=AFTER.

******Note Grand Mean at bottom of table*******

DESCRIPTIVES VARIABLES=BMP_MAI_GrandMean
  /STATISTICS=MEAN STDDEV.

********RQ3**************************


*****SAVE PLACE FOR RQ3******

********Collinearity Diagnostics using Peterson_PROBIT.sav*********

DATASET ACTIVATE DataSet2.
REGRESSION
  /MISSING LISTWISE
  /STATISTICS COLLIN TOL
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT Q10A_INS
  /METHOD=ENTER Q4 Q5 Q6 Q7 Q8 Q12 Q15 AGE Q19 Q21 Q22 Q34 WATT EATT Q17_RCD Q23_RCD
Q25_RCD
    Q26_RCD Q33_RCD Q35_RCD Q36_RCD Q1_RC Q2_RC OWN_PERCENT RENT_PERCENT Q32_RCD
Q30_RCD Q31_RCD
    Q24_RCD Q29_RCD.

******PCA for Multivariate Probit using Peterson_PROBIT.sav**********



*********RQ4*************************

****Item by Item*****

DESCRIPTIVES VARIABLES=Q11A Q11B Q11C Q11D Q11E Q11F Q11G Q11H Q11I Q11J Q11K Q11L Q11M
  /STATISTICS=MEAN STDDEV MIN MAX SKEWNESS.

* Custom Tables.
CTABLES
  /VLABELS VARIABLES=Q11A Q11B Q11C Q11D Q11E Q11F Q11G Q11H Q11I Q11J Q11K Q11L Q11M
    DISPLAY=LABEL
  /TABLE Q11A [C][COUNT F40.0, ROWPCT.VALIDN PCT40.0, TOTALS[COUNT F40.0, ROWPCT.VALIDN
PCT40.0,
    MEAN F40.1, STDDEV F40.2]] + Q11B [C][COUNT F40.0, ROWPCT.VALIDN PCT40.0, TOTALS[COUNT F40.0,
    ROWPCT.VALIDN PCT40.0, MEAN F40.1, STDDEV F40.2]] + Q11C [C][COUNT F40.0, ROWPCT.VALIDN
PCT40.0,
```

```
   TOTALS[COUNT F40.0, ROWPCT.VALIDN PCT40.0, MEAN F40.1, STDDEV F40.2]] + Q11D [C][COUNT
F40.0,
   ROWPCT.VALIDN PCT40.0, TOTALS[COUNT F40.0, ROWPCT.VALIDN PCT40.0, MEAN F40.1, STDDEV
F40.2]] + Q11E
   [C][COUNT F40.0, ROWPCT.VALIDN PCT40.0, TOTALS[COUNT F40.0, ROWPCT.VALIDN PCT40.0, MEAN
F40.1,
   STDDEV F40.2]] + Q11F [C][COUNT F40.0, ROWPCT.VALIDN PCT40.0, TOTALS[COUNT F40.0,
ROWPCT.VALIDN
   PCT40.0, MEAN F40.1, STDDEV F40.2]] + Q11G [C][COUNT F40.0, ROWPCT.VALIDN PCT40.0,
TOTALS[COUNT
   F40.0, ROWPCT.VALIDN PCT40.0, MEAN F40.1, STDDEV F40.2]] + Q11H [C][COUNT F40.0,
ROWPCT.VALIDN
   PCT40.0, TOTALS[COUNT F40.0, ROWPCT.VALIDN PCT40.0, MEAN F40.1, STDDEV F40.2]] + Q11I
[C][COUNT
   F40.0, ROWPCT.VALIDN PCT40.0, TOTALS[COUNT F40.0, ROWPCT.VALIDN PCT40.0, MEAN F40.1, STDDEV
F40.2]]
    + Q11J [C][COUNT F40.0, ROWPCT.VALIDN PCT40.0, TOTALS[COUNT F40.0, ROWPCT.VALIDN PCT40.0,
MEAN
   F40.1, STDDEV F40.2]] + Q11K [C][COUNT F40.0, ROWPCT.VALIDN PCT40.0, TOTALS[COUNT F40.0,
   ROWPCT.VALIDN PCT40.0, MEAN F40.1, STDDEV F40.2]] + Q11L [C][COUNT F40.0, ROWPCT.VALIDN
PCT40.0,
   TOTALS[COUNT F40.0, ROWPCT.VALIDN PCT40.0, MEAN F40.1, STDDEV F40.2]] + Q11M [C][COUNT
F40.0,
   ROWPCT.VALIDN PCT40.0, TOTALS[COUNT F40.0, ROWPCT.VALIDN PCT40.0, MEAN F40.1, STDDEV
F40.2]]
  /CLABELS ROWLABELS=OPPOSITE
  /CATEGORIES VARIABLES=Q11A Q11B Q11C Q11D Q11E Q11F Q11G Q11H Q11I Q11J Q11K Q11L Q11M
ORDER=A
   KEY=VALUE EMPTY=INCLUDE TOTAL=YES POSITION=AFTER.

******Note Grand Mean at bottom of table*******

DESCRIPTIVES VARIABLES=BMP_BAR_GrandMean.
  /STATISTICS=MEAN STDDEV.



*********RQ5*************************

****Item by Item*****

DESCRIPTIVES VARIABLES=Q13A Q13B Q13C Q13D Q13E Q13F
  /STATISTICS=MEAN STDDEV MIN MAX SKEWNESS.

* Custom Tables.
CTABLES
  /VLABELS VARIABLES=Q13A Q13B Q13C Q13D Q13E Q13F DISPLAY=LABEL
  /TABLE Q13A [C][COUNT F40.0, ROWPCT.VALIDN PCT40.0, TOTALS[COUNT F40.0, ROWPCT.VALIDN
PCT40.0,
   MEAN F40.2, STDDEV F40.2]] + Q13B [C][COUNT F40.0, ROWPCT.VALIDN PCT40.0, TOTALS[COUNT F40.0,
```

```
   ROWPCT.VALIDN PCT40.0, MEAN F40.2, STDDEV F40.2]] + Q13C [C][COUNT F40.0, ROWPCT.VALIDN
PCT40.0,
   TOTALS[COUNT F40.0, ROWPCT.VALIDN PCT40.0, MEAN F40.2, STDDEV F40.2]] + Q13D [C][COUNT
F40.0,
   ROWPCT.VALIDN PCT40.0, TOTALS[COUNT F40.0, ROWPCT.VALIDN PCT40.0, MEAN F40.2, STDDEV
F40.2]] + Q13E
   [C][COUNT F40.0, ROWPCT.VALIDN PCT40.0, TOTALS[COUNT F40.0, ROWPCT.VALIDN PCT40.0, MEAN
F40.2,
   STDDEV F40.2]] + Q13F [C][COUNT F40.0, ROWPCT.VALIDN PCT40.0, TOTALS[COUNT F40.0,
ROWPCT.VALIDN
   PCT40.0, MEAN F40.2, STDDEV F40.2]]
  /CLABELS ROWLABELS=OPPOSITE
  /CATEGORIES VARIABLES=Q13A Q13B Q13C Q13D Q13E Q13F ORDER=A KEY=VALUE EMPTY=INCLUDE
TOTAL=YES
   POSITION=AFTER.

******Note Grand Mean at bottom of table*******

DESCRIPTIVES VARIABLES=GCS_BAR_GrandMean.
  /STATISTICS=MEAN STDDEV.


******Filter of Non-Adopters of Q10G_INS, Q10J_INS, Q10P_INS, Q10Q_INS and Descriptives for Least
Adopted Practices************

COMPUTE filter_$=((Q10G_INS=0 AND Q10J_INS=0 AND Q10P_INS=0 AND Q10Q_INS=0) AND (Q11A>3
OR Q11B>3 OR Q11C>3 OR Q11D>3 OR Q11E>3 OR Q11F>3 OR Q11G>3 OR Q11H>3 OR
   Q11I>3 OR Q11J>3 OR Q11K>3 OR Q11L>3 OR Q11M>3)).
VARIABLE LABELS filter_$ 'Q10G_INS=0 OR Q10J_INS=0 OR Q10P_INS=0 OR Q10Q_INS=0 (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMATS filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE.



DESCRIPTIVES VARIABLES=Q11A Q11B Q11C Q11D Q11E Q11F Q11G Q11H Q11I Q11J Q11K Q11L Q11M
  /STATISTICS=MEAN STDDEV MIN MAX
  /SORT=MEAN (D).


*******Filter of Non-Adopters for ALL BMPs and Descriptives***************

COMPUTE filter_$=((Q10A_INS=0 AND Q10B_INS=0 AND Q10C_INS=0 AND Q10D_INS=0 AND
Q10E_INS=0 AND Q10F_INS=0 AND Q10G_INS=0
AND Q10H_INS=0 AND Q10I_INS=0 AND Q10J_INS=0 AND Q10K_INS=0 AND Q10L_INS=0 AND
Q10M_INS=0 AND Q10N_INS=0 AND Q10O_INS=0
AND Q10P_INS=0 AND Q10Q_INS=0 AND Q10R_INS=0) AND (Q11A>3 OR Q11B>3 OR Q11C>3 OR
Q11D>3 OR Q11E>3 OR Q11F>3 OR Q11G>3 OR Q11H>3 OR
   Q11I>3 OR Q11J>3 OR Q11K>3 OR Q11L>3 OR Q11M>3)).
VARIABLE LABELS filter_$ 'Q10G_INS=0 OR Q10J_INS=0 OR Q10P_INS=0 OR Q10Q_INS=0 (FILTER)'.
```

```
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMATS filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE.

COMPUTE BMP_BAR_2=MEAN(Q11A, Q11B, Q11C, Q11D, Q11E, Q11F, Q11G, Q11H, Q11I, Q11J, Q11K,
Q11L, Q11M).
VARIABLE LABELS BMP_BAR_2 "BMP_BAR_2e Grand Mean".
VARIABLE LEVEL /BMP_BAR_2 (SCALE).
EXECUTE.

DESCRIPTIVES VARIABLES=Q11A Q11B Q11C Q11D Q11E Q11F Q11G Q11H Q11I Q11J Q11K Q11L Q11M
  /STATISTICS=MEAN STDDEV MIN MAX
  /SORT=MEAN (D).


*******Filter of Non-Participants in GCSP**************

COMPUTE filter_$=((Q12=0) AND (Q13A>3 OR Q13B>3 OR Q13C>3 OR Q13D>3 OR Q13E>3 OR Q13F>3)).
VARIABLE LABELS filter_$ 'Q12=0 (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMATS filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE.

DESCRIPTIVES VARIABLES=Q13A Q13B Q13C Q13D Q13E Q13F
  /STATISTICS=MEAN STDDEV MIN MAX
  /SORT=MEAN (D).

**************LIMDEP SYNTAX**************
|-> SKIP$

|->
PROBIT;Lhs=X8;Rhs=ONE,X3,X4,X5,X6,X7,X26,X27,X28,X29,X32,X33,X34,X35,X3
6,X38,X41,X42,X44,X45,X46,X47,X48,X49,X50,X51,X52,X53,X54,X55,X65;Hold;
Margin
    ;Summarize;List$

|-> SKIP$

|->
PROBIT;Lhs=X9;Rhs=ONE,X3,X4,X5,X6,X7,X26,X27,X28,X29,X32,X33,X34,X35,X3
6,X38,X41,X42,X44,X45,X46,X47,X48,X49,X50,X51,X52,X53,X54,X55,X65;Hold;
Margin
    ;Summarize;List$

|-> SKIP$

|->
PROBIT;Lhs=X10;Rhs=ONE,X3,X4,X5,X6,X7,X26,X27,X28,X29,X32,X33,X34,X35,X
36,X38,X41,X42,X44,X45,X46,X47,X48,X49,X50,X51,X52,X53,X54,X55,X65;Hold
;Margin
```

```
    ;Summarize;List$

|-> SKIP$

|->
PROBIT;Lhs=X11;Rhs=ONE,X3,X4,X5,X6,X7,X26,X27,X28,X29,X32,X33,X34,X35,X
36,X38,X41,X42,X44,X45,X46,X47,X48,X49,X50,X51,X52,X53,X54,X55,X65;Hold
;Margin
    ;Summarize;List$

|-> SKIP$

|->
PROBIT;Lhs=X12;Rhs=ONE,X3,X4,X5,X6,X7,X26,X27,X28,X29,X32,X33,X34,X35,X
36,X38,X41,X42,X44,X45,X46,X47,X48,X49,X50,X51,X52,X53,X54,X55,X65;Hold
;Margin
    ;Summarize;List$

|-> SKIP$

|->
PROBIT;Lhs=X13;Rhs=ONE,X3,X4,X5,X6,X7,X26,X27,X28,X29,X32,X33,X34,X35,X
36,X38,X41,X42,X44,X45,X46,X47,X48,X49,X50,X51,X52,X53,X54,X55,X65;Hold
;Margin
    ;Summarize;List$

|-> SKIP$

|->
PROBIT;Lhs=X14;Rhs=ONE,X3,X4,X5,X6,X7,X26,X27,X28,X29,X32,X33,X34,X35,X
36,X38,X41,X42,X44,X45,X46,X47,X48,X49,X50,X51,X52,X53,X54,X55,X65;Hold
;Margin
    ;Summarize;List$

|-> SKIP$

|->
PROBIT;Lhs=X15;Rhs=ONE,X3,X4,X5,X6,X7,X26,X27,X28,X29,X32,X33,X34,X35,X
36,X38,X41,X42,X44,X45,X46,X47,X48,X49,X50,X51,X52,X53,X54,X55,X65;Hold
;Margin
    ;Summarize;List$

|-> SKIP$

|->
PROBIT;Lhs=X16;Rhs=ONE,X3,X4,X5,X6,X7,X26,X27,X28,X29,X32,X33,X34,X35,X
36,X38,X41,X42,X44,X45,X46,X47,X48,X49,X50,X51,X52,X53,X54,X55,X65;Hold
;Margin
    ;Summarize;List$

|-> SKIP$

|->
PROBIT;Lhs=X17;Rhs=ONE,X3,X4,X5,X6,X7,X26,X27,X28,X29,X32,X33,X34,X35,X
```

```
36,X38,X41,X42,X44,X45,X46,X47,X48,X49,X50,X51,X52,X53,X54,X55,X65;Hold
;Margin
    ;Summarize;List$

|-> SKIP$

|->
PROBIT;Lhs=X18;Rhs=ONE,X3,X4,X5,X6,X7,X26,X27,X28,X29,X32,X33,X34,X35,X
36,X38,X41,X42,X44,X45,X46,X47,X48,X49,X50,X51,X52,X53,X54,X55,X65;Hold
;Margin
    ;Summarize;List$

|-> SKIP$

|->
PROBIT;Lhs=X19;Rhs=ONE,X3,X4,X5,X6,X7,X26,X27,X28,X29,X32,X33,X34,X35,X
36,X38,X41,X42,X44,X45,X46,X47,X48,X49,X50,X51,X52,X53,X54,X55,X65;Hold
;Margin
    ;Summarize;List$

|-> SKIP$

|->
PROBIT;Lhs=X20;Rhs=ONE,X3,X4,X5,X6,X7,X26,X27,X28,X29,X32,X33,X34,X35,X
36,X38,X41,X42,X44,X45,X46,X47,X48,X49,X50,X51,X52,X53,X54,X55,X65;Hold
;Margin
    ;Summarize;List$

|-> SKIP$

|->
PROBIT;Lhs=X21;Rhs=ONE,X3,X4,X5,X6,X7,X26,X27,X28,X29,X32,X33,X34,X35,X
36,X38,X41,X42,X44,X45,X46,X47,X48,X49,X50,X51,X52,X53,X54,X55,X65;Hold
;Margin
    ;Summarize;List$

|-> SKIP$

|->
PROBIT;Lhs=X22;Rhs=ONE,X3,X4,X5,X6,X7,X26,X27,X28,X29,X32,X33,X34,X35,X
36,X38,X41,X42,X44,X45,X46,X47,X48,X49,X50,X51,X52,X53,X54,X55,X65;Hold
;Margin
    ;Summarize;List$

|-> SKIP$

|->
PROBIT;Lhs=X23;Rhs=ONE,X3,X4,X5,X6,X7,X26,X27,X28,X29,X32,X33,X34,X35,X
36,X38,X41,X42,X44,X45,X46,X47,X48,X49,X50,X51,X52,X53,X54,X55,X65;Hold
;Margin
    ;Summarize;List$

|-> SKIP$
```

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|->
PROBIT;Lhs=X24;Rhs=ONE,X3,X4,X5,X6,X7,X26,X27,X28,X29,X32,X33,X34,X35,X
36,X38,X41,X42,X44,X45,X46,X47,X48,X49,X50,X51,X52,X53,X54,X55,X65;Hold
;Margin
    ;Summarize;List$

|-> SKIP$

|->
PROBIT;Lhs=X25;Rhs=ONE,X3,X4,X5,X6,X7,X26,X27,X28,X29,X32,X33,X34,X35,X
36,X38,X41,X42,X44,X45,X46,X47,X48,X49,X50,X51,X52,X53,X54,X55,X65;Hold
;Margin
    ;Summarize;List$
```

APPENDIX H

COLLINEARITY DIAGNOSTICS FOR INDEPENDENT VARIABLES

Coefficients[a]

Model		Collinearity Statistics	
		Tolerance	VIF
1	4. Are you aware of the term best management practice (BMP)?	.702	1.424
	5. Are you aware of the term nonpoint source pollution (NPS)?	.483	2.072
	6. Are you aware the major cause of impairment in Texas water bodies is due to elevated levels of bacteria?	.751	1.331
	7. Are you aware of the efforts to control nonpoint sources of water pollution through the Clean Water Act?	.543	1.840
	8. Are you aware financial assistance is available from agencies and organizations to help implement best management practices to control nonpoint sources of pollution?	.689	1.452
	12. Have you ever participated in a government funded cost-share program?	.506	1.975
	15. Are you male or female?	.727	1.375
	16. Your age (as of Dec 31, 2013)	.490	2.040
	19. How many acres of land are included in your entire farm operation?	.740	1.352
	21. How many years have you been running your livestock operation?	.579	1.727
	22. How many years do you intend to continue running your livestock operation?	.783	1.278
	34. Are you a member of a Texas livestock organization?	.713	1.402
	Water Quality Attitude	.635	1.575
	Environmental Attitude	.555	1.802
	Bachelor's Degree Dummy	.683	1.463
	Family Members working on Farm Dummy	.638	1.568
	Visits with Extension in 2012 Dummy	.585	1.710
	Visits with NRCS in 2012 Dummy	.339	2.946
	Risk Aversion Dummy	.736	1.359
	Nearest Water Body Dummy	.719	1.391
	Water Quality Rating	.724	1.382
	Diversity of Livestock	.683	1.465
	Diversity of Crops	.779	1.284
	Percentage of Land Owned : Total Land Operated	.364	2.747
	Percentage of Land Rented : Total Land Operated	.339	2.948
	Debt:Asset Ratio Dummy	.694	1.442
	% Income From Operation Dummy	.709	1.411
	% Income From Off-Farm Source Dummy	.824	1.213
	Family members taking over farm	.696	1.437
	Annual income	.676	1.478

a. Dependent Variable: 10a. BMP Installed - Control access of animals and machinery to sensitive areas

Model	Dimension	Eigenvalue	Condition Index	(Constant)	4. Are you aware of the term best management practice (BMP)?	5. Are you aware of the term nonpoint source pollution (NPS)?	6. Are you aware the major cause of impairment in Texas water bodies is due to elevated levels of bacteria?	7. Are you aware of the efforts to control nonpoint sources of water pollution through the Clean Water Act?	8. Are you aware financial assistance is available from agencies and organizations to help implement best management practices to control nonpoint sources of pollution?	12. Have you ever participated in a government funded cost-share program?	15. Are you male or female?	16. Your age (as of Dec 31, 2013)	19. How many acres of land are included in your entire farm operation?	21. How many years have you been running your livestock operation?
1	1	16.697	1.000	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	2	1.512	3.324	.00	.00	.03	.00	.03	.07	.02	.00	.00	.01	.00
	3	1.454	3.389	.00	.00	.01	.02	.01	.02	.02	.00	.00	.16	.00
	4	1.094	3.906	.00	.00	.00	.01	.00	.01	.01	.00	.00	.00	.00
	5	1.020	4.045	.00	.00	.00	.00	.00	.01	.00	.00	.00	.00	.00
	6	1.003	4.081	.00	.01	.03	.01	.01	.00	.01	.00	.00	.04	.01
	7	.829	4.487	.00	.00	.01	.01	.01	.07	.00	.00	.00	.16	.01
	8	.765	4.672	.00	.04	.01	.03	.02	.08	.01	.00	.00	.00	.00
	9	.691	4.917	.00	.00	.02	.01	.01	.04	.01	.00	.00	.00	.00
	10	.662	5.022	.00	.00	.01	.04	.00	.05	.00	.00	.00	.04	.00
	11	.629	5.154	.00	.00	.01	.00	.04	.02	.01	.00	.00	.03	.00
	12	.562	5.449	.00	.00	.03	.16	.01	.00	.00	.00	.00	.00	.00
	13	.489	5.846	.00	.00	.00	.03	.01	.04	.00	.00	.00	.33	.01
	14	.424	6.279	.00	.07	.08	.31	.01	.13	.02	.00	.00	.01	.00
	15	.412	6.370	.00	.02	.08	.00	.04	.28	.04	.00	.00	.02	.02
	16	.385	6.584	.00	.00	.01	.00	.04	.06	.11	.00	.00	.00	.03
	17	.356	6.847	.00	.03	.04	.09	.12	.04	.02	.00	.00	.04	.01
	18	.320	7.223	.00	.02	.02	.01	.07	.00	.02	.00	.00	.00	.02
	19	.302	7.437	.00	.11	.00	.07	.15	.00	.16	.00	.00	.00	.02
	20	.284	7.663	.00	.26	.17	.07	.05	.00	.07	.00	.00	.01	.00
	21	.235	8.438	.00	.07	.02	.01	.01	.00	.01	.00	.00	.04	.04
	22	.216	8.789	.00	.12	.04	.00	.01	.00	.09	.00	.00	.04	.24
	23	.187	9.459	.00	.00	.07	.08	.29	.04	.21	.01	.00	.02	.26
	24	.147	10.647	.00	.02	.01	.01	.00	.00	.10	.03	.00	.01	.00
	25	.119	11.835	.00	.15	.13	.00	.00	.00	.00	.00	.00	.00	.06
	26	.072	15.251	.00	.02	.06	.00	.02	.00	.00	.24	.00	.01	.00
	27	.054	17.571	.00	.01	.04	.00	.01	.00	.01	.22	.00	.00	.06
	28	.046	19.044	.00	.02	.00	.00	.00	.03	.03	.39	.02	.01	.00
	29	.022	27.650	.00	.01	.00	.03	.00	.00	.02	.00	.40	.01	.16
	30	.010	40.860	.00	.00	.02	.00	.00	.00	.00	.01	.15	.00	.03
	31	.003	73.267	.99	.00	.02	.00	.01	.02	.00	.08	.42	.00	.02

a. Dependent Variable: 10a. BMP Installed - Control access of animals and machinery to sensitive areas

Collinearity Diagnostics[a]

Variance Proportions																			
22. How many years do you intend to continue running your livestock operation?	34. Are you a member of a Texas livestock organization?	Water Quality Attitude	Environmental Attitude	Bachelor's Degree Dummy	Family Members working on Farm Dummy	Visits with Extension in 2012 Dummy	Visits with NRCS in 2012 Dummy	Risk Aversion Dummy	Nearest Water Body Dummy	Water Quality Rating	Diversity of Livestock	Diversity of Crops	Percentage of Land Owned : Total Land Operated	Percentage of Land Rented : Total Land Operated	Debt:Asset Ratio Dummy	% Income From Operation Dummy	% Income From Off-Farm Source Dummy	Family members taking over farm	Annual income
.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
.03	.00	.00	.00	.00	.00	.01	.02	.00	.00	.00	.00	.00	.00	.00	.01	.00	.00	.00	.00
.01	.03	.00	.00	.00	.00	.00	.01	.00	.00	.01	.00	.01	.00	.00	.04	.00	.00	.01	.00
.20	.01	.00	.00	.01	.00	.00	.00	.00	.00	.01	.01	.13	.00	.03	.02	.00	.00	.01	.00
.27	.00	.00	.00	.00	.02	.00	.00	.00	.01	.00	.00	.11	.00	.00	.11	.00	.00	.00	.01
.05	.03	.00	.00	.00	.00	.00	.00	.00	.01	.01	.00	.00	.01	.01	.18	.00	.00	.01	.00
.03	.11	.00	.00	.01	.01	.00	.00	.01	.03	.02	.02	.00	.00	.00	.03	.00	.00	.01	.02
.01	.04	.00	.00	.01	.00	.01	.00	.01	.01	.02	.05	.02	.00	.00	.02	.00	.00	.14	.00
.00	.11	.00	.00	.02	.04	.01	.00	.01	.00	.07	.05	.07	.01	.02	.00	.00	.00	.00	.04
.11	.07	.00	.00	.12	.02	.02	.01	.01	.02	.00	.01	.02	.00	.03	.00	.00	.00	.02	.01
.02	.00	.00	.00	.00	.00	.00	.00	.00	.15	.01	.26	.07	.00	.00	.01	.00	.00	.00	.03
.00	.15	.00	.00	.01	.00	.00	.01	.00	.07	.00	.01	.21	.00	.02	.02	.00	.00	.07	.00
.03	.03	.00	.00	.00	.01	.02	.03	.02	.15	.04	.01	.05	.00	.00	.11	.00	.00	.06	.00
.00	.07	.00	.00	.07	.01	.06	.02	.01	.03	.00	.00	.02	.00	.00	.00	.00	.00	.00	.02
.00	.00	.00	.00	.20	.00	.03	.01	.01	.01	.02	.02	.06	.00	.00	.00	.01	.00	.09	.01
.00	.01	.00	.00	.07	.01	.30	.00	.00	.04	.05	.02	.01	.01	.01	.01	.00	.00	.05	.01
.03	.00	.00	.00	.00	.08	.00	.01	.13	.02	.23	.00	.01	.00	.00	.00	.00	.00	.03	.03
.00	.00	.00	.00	.00	.04	.09	.01	.00	.17	.12	.11	.01	.01	.06	.20	.00	.00	.12	.02
.02	.07	.00	.00	.04	.14	.01	.00	.05	.00	.03	.05	.07	.00	.00	.00	.03	.00	.02	.06
.00	.01	.00	.00	.00	.05	.05	.02	.02	.06	.03	.00	.00	.01	.00	.01	.06	.00	.04	.03
.00	.08	.00	.00	.00	.25	.02	.06	.05	.00	.00	.11	.03	.00	.01	.02	.01	.00	.01	.45
.00	.06	.00	.00	.09	.02	.01	.02	.17	.00	.04	.07	.00	.00	.00	.04	.01	.00	.05	.18
.00	.00	.00	.00	.13	.00	.00	.08	.11	.07	.05	.01	.01	.01	.02	.02	.00	.00	.01	.00
.02	.01	.00	.00	.03	.11	.19	.51	.19	.02	.18	.05	.01	.01	.00	.00	.01	.00	.17	.00
.05	.01	.00	.00	.00	.01	.06	.03	.01	.00	.00	.00	.00	.04	.10	.03	.70	.02	.05	.01
.01	.01	.00	.00	.05	.00	.01	.04	.00	.00	.02	.01	.01	.64	.39	.01	.05	.01	.00	.00
.00	.03	.00	.00	.03	.02	.04	.03	.02	.00	.00	.00	.01	.04	.05	.02	.00	.71	.00	.01
.04	.00	.06	.06	.02	.01	.00	.00	.13	.00	.00	.08	.02	.08	.06	.02	.04	.11	.00	.00
.00	.02	.01	.27	.02	.09	.00	.00	.00	.00	.00	.01	.00	.01	.00	.02	.04	.06	.02	.00
.02	.01	.69	.55	.03	.03	.04	.00	.00	.10	.00	.02	.00	.01	.02	.01	.00	.07	.00	.03
.04	.02	.24	.11	.02	.00	.02	.08	.03	.02	.04	.00	.03	.09	.15	.03	.05	.01	.00	.03